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The impact of modeling and simulation on the Army acquisition process

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THE IMPACT OF
MODELING AND SIMULATION
ON THE ARMY ACQUISITION PROCESS

by

Thomas W. Crouch

March 1994

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The purpose of this thesis is to identify and analyze the potential capabilities and limitations of the modeling and simulation (M&S) strategy used by the U.S. Army for acquisition purposes. This thesis considers the Army's current acquisition process, M&S technologies and the Army's organizational infrastructure to ascertain whether or not they adequately address cited goals. Specifically, the programmatics of DoD's 5000 series are evaluated to see if they support the concurrent processes afforded by M&S.

The research indicates that the Army should focus on enhancing its requirements generation process by adequately supporting its Battle Labs. The degree to which M&S will impact the Army acquisition process is dependent on how well M&S and Battle Labs are represented in the Future Years Defense Plan. Recommendations in the areas of acquisition programmatics and Army organizational infrastructure are provided in an attempt to enhance the application of M&S in the Army's acquisition process.

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The Impact of Modeling and Simulation
on the Army Acquisition Process
by

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to identify, describe, and analyze the potential capabilities and limitations of the modeling and simulation (M&S) strategy used by the U.S. Army for acquisition purposes. From the analysis a set of recommendations in the areas of acquisition progrommatics, technology infrastructure, and organizational infrastructure are provided in an attempt to enhance the application of M&S in the Army's acquisition process.

B. BACKGROUND

Modeling and simulation represents an explosive growth industry within the U.S. Defense Department. The technologies comprising these revolutionary techniques are receiving increasingly wider application among the Services, and in particular the Army, as the Department of Defense (DoD) budget continues to plummet. (Williams,1993,p.16)

As M&S capabilities increase, and the amount of defense spending decreases, M&S surfaces as a more critical aspect of a weapon system's acquisition strategy. This technology portends reduction of costly mistakes by allowing the Army to define and test its requirements very early in the acquisition cycle.

Lieutenant General William H. Forster, the Military Deputy to the Assistant Secretary of the Army (Research, Development and Acquisition), reinforced the need for M&S integration into the Army acquisition process. In his 24 May 1993 Memorandum for the Deputy Commanding General, U.S. Army Materiel Command and all Program Executive Officers, under the subject of "Simulation Support to the Army", LTG Forster states:

> The Army Science Board and Defense Science Board have recently studied the potential improvements to DoD acquisition offered by advanced simulation, particularly Distributed Interactive Simulation (DIS). Both concluded that simulation can improve acquisition from concept to fielding through such innovations as: virtual prototyping; engineering simulation; linking of constructive, virtual and/or live simulations; assisting the user in execution of experiments in employment tactics; user test design and critical issue identification; and improved training prior to fielding.
>
> The Army is leading the way for DoD in simulation with such initiatives as Battlefield Distributed Simulation-Developmental, Close Combat Tactical Trainer, and DIS Modernization and Master Plans. We need to take full advantage from concept to fielding. Effective second quarter fiscal year 1994, all Army acquisition strategies for Acquisition Category I and II programs will include a simulation support plan. Additionally, the simulation support plan must be included in the Program Manager's ASARC briefing. Other programs may be tasked by the Army Acquisition Executive to include a simulation support plan. (Forster,1993,p.1)

Simulation technologies as evidenced by LTG Forster's comments are the focal point of intensive research. Advances are rapidly unfolding in this arena and Pentagon interest, which usually translates into increasing funding, is regarded as intense. Experts point to the absolute necessity of

developing and fielding an improved M&S architecture for readiness, operations and acquisition. (Williams,1993,p.16)

The Army's M&S resources have been predominantly used in the areas of training and analysis. The Army has increased the capability of its high resolution modeling facilities and is making dramatic progress in the area of three dimensional simulation. These advancements have generated high expectations that within the next few years the M&S community will field the requisite fidelity and distributed capabilities needed to streamline the current acquisition process.

C. THESIS OBJECTIVE

This thesis considers the Army's current acquisition process, M&S technologies and the Army's organizational infrastructure to ascertain whether or not they adequately address cited goals. Specifically, the programmatics of DoD's 5000 series, which addresses the policies and procedures for DoD and Army acquisition, are evaluated to see if they support the concurrent processes afforded by M&S. Secondly, the near, mid, and long range capabilities of the Army's M&S technologies are assessed to ascertain what level of confidence acquisition professionals and DoD leaders should place in these assets. Finally, the Army's current organizational structure is evaluated to determine whether it can facilitate the successful implementation of M&S technology for acquisition streamlining.

D. RESEARCH QUESTIONS

The primary research question of this thesis is:

- What constructs can be formulated which enable modeling and simulation to impact beneficially on the Army acquisition process?

The three subsidiary questions are:

- Does the DoD 5000 series support the vision of streamlined acquisition through the use of modeling and simulation?
- Can this vision of increased use of modeling and simulation, within the Army acquisition process, be supported by the current allotment of Research, Development, Test and Evaluation (RDT&E) funding?
- Does the Army's organizational structure maximize the potential of modeling and simulation on the acquisition process?

E. SCOPE AND LIMITATIONS

Three major areas are analyzed to determine the best method, and potential pitfalls, of integrating current and future M&S capabilities into the Army's acquisition architecture. They are: acquisition programmatics; Army acquisition organizational structure; and the Army's M&S technology infrastructure. All three represent critical and interdependent portions of the acquisition process that must be evaluated if the objective of acquisition streamlining is to be met.

A major portion of the thesis concentrates on the applicability of the current DoD 5000 series regulating U.S.

Defense acquisition. While the DoD 5000 series covers all four Services' acquisition policy this paper focuses solely on its impacts within the U.S. Army.

The M&S strategy presented includes most major M&S programs ongoing at the time this document was written but is not inclusive of all technologies residing within the M&S architecture. The programs mentioned do, however, cover technologies from the major areas within the M&S community to provide the reader an appreciation for the capabilities derived from the integration of these assets.

Organizational issues discussed are limited to the Major Commands or Offices within the Department of the Army that deal directly, or primarily, with Army acquisition policy and issues.

F. LITERATURE REVIEW AND METHODOLOGY

Research data were obtained from professional materials, articles, previous theses, DoD and Army manuals and briefings, and personal interviews. Information on current M&S programs was obtained from various Army Training and Doctrine Command (TRADOC) Analysis Centers (TRACs), the Institute for Simulation and Training at the University of Central Florida, the Army's Simulation, Training and Instrumentation Command (STRICOM), the Test and Experimentation Command (TEXCOM), and the Defense Modeling and Simulation Office (DMSO).

Most of the research was conducted during on-site visits or telephone interviews. The major thrusts of questions asked focused on whether the Army is postured in terms of policy, technology, funding and organizational structure to advantage the capabilities of current and forthcoming M&S potential. In addition, the DoD 5000 series and the Army acquisition organizational structure were examined to determine whether or not their architecture would house the future methods of conducting acquisition business. The final area of analysis focused on the RDT&E funding levels provided for Army M&S to see if this would afford the realization of the Army's M&S vision.

G. ACRONYMS

As with most military topics M&S has established its own vocabulary of acronyms. The list of these terms is quite extensive and contained in Appendix A.

H. ORGANIZATION OF STUDY

Chapter II of this thesis addresses the recent administrative and political events that have shaped the Army's current acquisition strategy. Chapter III discusses acquisition programmatics such as the DoD 5000 series, the acquisition life cycle model, and the RDT&E funding requirements, then reviews the organizational structure that supports the Army acquisition process. Chapter IV takes an

in-depth look at the Army’s M&S strategy and the associate driving technologies. Chapters V and VI contain the information analysis, and the conclusions and recommendations, respectively.

II. THE EVOLUTION OF TODAY'S ACQUISITION STRATEGY

A. GENERAL

Over the past 30 years the Federal Government has sought to provide the military with a strategy that would optimize the acquisition process. These major acquisition reforms sought to reduce cost and schedule overruns, increase program stability, emphasize realistic testing, and improve the efficiency of the acquisition process. The following initiatives, which date back to the McNamara era of the early 1960's have all had one common underlying theme - reduce cost and schedule overruns while enhancing system performance:

- McNamara Initiatives (1961)
- Commission on Government Procurement (1972)
- Office of Management and Budget Circular A-109 (1976)
- Defense Science Board Acquisition Cycle Study (1978)
- Defense Resource Management Study (1979)
- Defense Acquisition Improvement Program (1981)
- Grace Commission (1983)
- Packard "Blue Ribbon" Commission (1986)
- Goldwater - Nichols Defense Reorganization Act (1986)
- Defense Management Review (1989) (GAO,1992,p.53)

With so much emphasis over the years on acquisition process and strategy it seems inconceivable to still encounter program debacles such as the B-1 Bomber, the C-17 Cargo Aircraft, and the A-12 Attack Aircraft. Yet to this very day cost and schedule overruns and failure to meet user requirements still haunt many program mangers.

The 1992 GAO report on "Weapons Acquisition - A Rare Opportunity for Lasting Change", states that, "We believe that past acquisition reforms have had limited effectiveness because they have not changed the basic incentives or pressures that drive the behavior of the participants of the process". (GAO,1992,p.53)

Ironically, in the pursuit of a more perfect acquisition process, it was the dismantling of the Warsaw Pact and the Soviet Union that provided the catalyst for the current round of acquisition revisions. In his 20 May 1992 Memorandum to the Secretaries of the Military Departments, on the subject of Defense Acquisition, Under Secretary of Defense for Acquisition Don Yockey stated:

> With the breakup of the Warsaw Pact and the dissolution of the Soviet Union, the pressure of rapidly advancing high technology weapons in the arsenals of potential enemies has also significantly lessened. Consequently, the need to replace existing weapon systems in order to maintain a significant technological advantage is no longer as urgent. As a result, we will be able to reduce concurrency in development programs and retain existing equipment for longer periods, with the necessary technological advances incorporated more often through upgrades than through initiation of new systems. The reduced urgency for modernization, coupled with the

smaller armed forces, means the Department will acquire fewer weapons systems and that the acquisition budget will be reduced accordingly.

> Although we will reduce the quantity of new weapons produced, the need to maintain technological superiority, a key combat force multiplier, will drive us to increase efforts in developing new and innovative technology. There are seven areas (Seven Science and Technology Thrusts) in the expanded Science and Technology (S&T) Program which provide a focus for the development of new and promising ideas, including those related to manufacturing processes. Additional funding allocated to the seven areas will provide the opportunity for the best of these ideas to be proven in Advanced Technology Demonstrations (ATDs). These ATDs will be focused on validating the maturity and utility of advanced technologies and will, thereby, reduce performance, cost, and schedule risks in future acquisition programs. (Yockey,1992,p.1)

B. SCIENCE AND TECHNOLOGY THRUSTS

To provide the focus for the S&T program, seven broad areas of capability have to be defined. These Seven Thrusts represent the current assessment of the areas on which the S&T program should be focussed to address the users' most pressing military and operational needs. While there are goals and activities in the S&T program which fall outside of these thrusts, it is crucial to the maintenance of our technological superiority that our investments and energies be focused on those efforts which are the most important to -- which show the greatest promise for improving -- future military capabilities. (Charles,WP#3,1992,p.2)

The Seven Thrusts are:

1. Global Surveillance and Communications. To project power requires a global surveillance and communications capability that can focus on a trouble spot, surge in capacity, and be responsive to the needs of the commander.

2. Precision Strike. The goals of increasing the effectiveness of weapons and reducing casualties, while using fewer weapons platforms, demand that we locate high-value, time-sensitive fixed and mobile targets and destroy them with a high degree of confidence.

3. Air Superiority and Defense. The need to defend deployed military forces from ballistic and cruise missiles and to maintain our current decisive capabilities in air combat, interdiction, and close air support requires a focussed effort in missile defense and air superiority.

4. Sea Control and Undersea Superiority. To maintain an overseas presence, conduct forcible entry and naval interdiction operations, and operate in littoral zones requires superiority in sea control and undersea warfare.

5. Advanced Land Combat. The ability to rapidly deploy our ground forces to a region, exercise a high degree of tactical mobility, and neutralize the enemy quickly and with minimal casualties in the presence of a heavy armored threat and smart weaponry requires highly capable and survivable land combat systems.

6. Synthetic Environments. A broad range of information and human interaction technologies must be developed to synthesize present and future battlefields, identify critical problem areas, and speed the development of cost-effective solutions. Synthetic battlefields will involve a mix of real and computer-simulated equipment. Integrated teams of users, developers, and/or testers will be able to interact effectively. Synthetic environments will prepare our leaders and forces for war.

7. Technology for Affordability. Technologies that will reduce unit and life cycle costs are essential to achieving significant performance and affordability improvements. Advances are particularly needed in technologies to support integrated product and process design, flexible manufacturing systems that separate cost from volume, enterprise-wide information systems that improve program control and reduce overhead cost, and integrated software engineering environments. (Charles,WP#3,1992,p.4)

M&S potential has the recognition of senior civilian and military leaders. With their attention, acquisition streamlining can be accomplished through the continued implementation and integration of current M&S technologies as researchers continue to develop S&T thrust areas six and seven.

From within each of these thrust areas Advanced Technology Demonstrations (ATDs) will be developed. The critical challenge will be to maintain the scientific and technological continuity as findings are transferred from basic research to exploratory development. It is also imperative that the warfighter be directly involved in this process so that the system requirements for the user are identified early in the acquisition process.

C. ADVANCED TECHNOLOGY DEMONSTRATIONS

Advanced technology demonstration efforts are structured to develop and integrate hardware for field experiments and tests; this is the demonstration phase of S&T. Candidates include those that have successfully transitioned from research and exploratory development and those which may have evolved from independent industry or other efforts. The ATD program provides funding to develop and fabricate hardware and software to evaluate performance, military utility, and affordability issues. (Charles,WP#4,1992,p.3)

There are generally two types of ATDs: those focused on new system and subsystem concepts and those focused on "enabling" technologies. Demonstrations of capability, coupled with simulation and exercises, will help ensure that the technology is ready and affordable, manufacturing processes are available, and operating concepts are understood before committing to a formal acquisition program. What is new is the scope and depth of ATDs and the increased importance of their role in the acquisition process, and the emphasis on user involvement to permit an early and meaningful evaluation of military capability. (Charles,WP#3,1992,p.2)

The distinction between ATDs and acquisition programs is explained as follows: ATDs are part of the science and technology base, focused on validating viability and producibility of technology. Acquisition programs are only undertaken when there is a clear military need, technologies have been demonstrated and tested, and the new system or upgrade is cost-effective. Further, before technologies from science and technology projects transition to a formal acquisition program, the mission need must have been validated and approved at Milestone 0. (Cochrane,August,1992,p.43)

The purpose of the S&T and ATD programs is to provide for the availability and integration of advanced technology to meet military needs. The S&T/ATD strategy emphasizes meeting the needs of the fighting forces while at the same time making available new technologies to meet pressing operational

problems. This strategy is structured to focus the S&T program in order to maintain a position of technological superiority that is essential for the success of America's military forces. (Charles,WP#3,1992,p.17)

D. FORMER SECRETARY ASPIN'S ACQUISITION STRATEGY

Former Secretary of Defense Aspin's "New Acquisition Strategy" deviated little from Mr Yockey's. Aspin's policy called for:

- Increased research on advanced technologies
- Increased development and evaluation of ATDs
- ATDs that will lead to upgrades to current systems or new capabilities that will be put into system development and production
- A strategy that is coupled to the existing DoD system as defined in DoDD 5000.1/DoDI 5000.2 (Aspin,1993,p.1)

The primary objective of Aspin's acquisition strategy is to effect the successful transition of technology to operational utility. This has been an area that the U.S. has been traditionally weak in and where the proper integration of M&S technologies will pay tremendous dividends in lending both solutions and continuity. (OTA,1989,p.53)

Aspin seems to be very attuned to this fact and the capabilities of M&S. He feels that the demonstrations of capability, coupled with advanced simulation techniques, will lead to a comprehensive assessment of:

- Technical feasibility (will it/does it work?)
- Affordability (is it cost effective/can we afford it?)
- Operational utility (does it meet a valid combat need?) (Aspin,1993,p.3)

The transition from S&T Thrusts to ATDs to weapon systems production appears to be the direction of DoD and the Army's acquisition process. Subsequent chapters of this thesis address how the integration of M&S technologies, within the appropriate vehicle, can facilitate the transfer of technology from S&T Thrusts, to weapon system utilization, in the most efficient and cost effective manner.

III. ACQUISITION PROGRAMMATICS AND ORGANIZATIONAL STRUCTURE

A. OVERVIEW

Colleen A. Preston, Deputy Under Secretary of Defense for Acquisition Reform, made the following proclamation in her Proposed Strategic Plan to Pursue Acquisition Reform;

> The Department of Defense faces an unprecedented challenge in preserving force effectiveness in the light of the radically altered and ever changing threat. To ensure, as the President and Secretary of Defense have committed, that we will not have a 'hollow force', but will maintain the edge we have over opponents in terms of quality of people, training, and technology, will not be easy. Maintaining readiness and protecting our technological superiority in today's environment means we must protect funding in the readiness accounts and for the science and technology programs.
>
> To pay for these priorities in a declining defense budget we must make major reductions in our other accounts, including our modernization accounts, and, we must find ways to dramatically reduce our 'infrastructure' or cost of doing business. That 'infrastructure' includes a number of functions and areas that must be addressed. One of those is the acquisition structure that has evolved over the years, but is no longer responsive to today's needs.
>
> We have today an acquisition system that evolved through the adoption of a myriad of rules, regulations, and laws that were intended to address a particular problem or public interest. The combined net effect of those rules, regulations, and laws is a system whose costs exceed any demonstrable benefit. In addition, these rules and regulations add costs to products of defense contractors, preventing them from being competitive in the commercial marketplace, and prevent commercial contractors unwilling to change their ways from selling to the government. In the past we could rely on incremental improvements to the system. To meet today's challenges we must revolutionize the process. (Preston,1993,p.3)

What is it about the DoD's acquisition process that seems to make it so inapplicable to today's requirements? To simply say that the entire process is broken lends little to providing a solution. This chapter addresses current acquisition programmatics and organizational structure to determine how it facilitates today's acquisition process. This review will lay the foundation for the analysis in Chapter V which will identify what is still relevant, or obsolete, within the acquisition process and community to evaluate how the Army's M&S assets can generate a more streamlined acquisition process.

B. DOD 5000 SERIES

The DoD "5000 series" is comprised of the following three documents. The DoD Directive 5000.1, "Defense Acquisition"; DoD Instruction 5000.2, "Defense Acquisition Management Policies and Procedures"; and DoD Manual 5000.2M, "Defense Acquisition Management Documents and Reports", all dated 23 February 1991. This new 5000 series provides a single uniform acquisition system for all DoD acquisition programs including: Major defense acquisition programs, non-major defense acquisition programs, and highly sensitive classified programs. This is an attempt to forge an interface among the requirements generation system, the acquisition management system, and the planning, programming and budgeting system (PPBS). The 5000 series contends that these three major

decision-making support systems must interface effectively for the acquisition process to work (Figure 1). (Cochrane,May-June,1992,p.29)

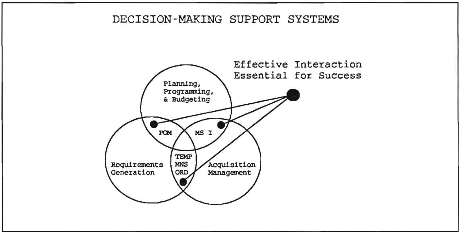

Figure 1 Decision Making Support Systems

1. Decision-Making Support System

As noted before, the authors of the 5000 series felt it imperative that the three major decision-making support systems interface effectively for the acquisition process to function as designed. It is worthwhile to examine each of these support systems to reveal what each is responsible for and how they relate to one another.

a. Requirements Generation System

Requirements generation is based on a continuing process of assessing the capabilities of the current force

structure (people and materiel) to meet the projected threat, while taking into account opportunities for technological advancement, cost savings, and changes in national policy or doctrine. The output of this process, known as mission area analysis (MAA), is a deficiency, or a mismatch between current capabilities and the projected threat. Once identified, deficiencies need to be resolved, and the first choice is a change in organization, doctrine or tactics, or perhaps additional training. These alternatives, often called non-materiel alternatives, are investigated first because of their relatively low cost and ease of implementation. Should non-materiel alternatives prove incapable of resolving the deficiency, we then proceed to look for materiel solutions. Once a determination is made that a materiel solution is required to satisfy the deficiency, a Mission Need Statement (MNS) documents the deficiency in the operational capability, not in system specific terms. (Schmoll,1993,p.21)

The MNS includes the applicable Defense Guidance element, the threat, the mission role of the system, any optional concepts, cooperative opportunities, technologies involved, funding aspects and implications, possible constraints, and the acquisition strategy. It is one of many documents prepared for Milestone I review.

Milestone I approval requires several documents, of which the most important programmatically are the Operational Requirements Document (ORD), the Test and Evaluation Master

Plan (TEMP), and the Cost and Operational Effectiveness Analysis (COEA).

The ORD details the performance and related operational parameters for the concept or system proposed in meeting the deficiencies addressed in the MNS. It establishes the minimum acceptable requirements for the concept or system. The TEMP documents the test and evaluation strategy, objectives, schedule, and required resources of effort in order to verify that the performance requirements established by the ORD will be met. The COEA is a stand alone report, unique, separate from, but consistent with, other analytical efforts supporting defense acquisition management. The COEA is structured to define cost, military capabilities and operational benefits associated with principal materiel alternatives that address validated mission needs. Once issued the ORD, the TEMP, and the COEA become continuing documents requiring updating and approval at each milestone, and in effect are the primary documents for exerting Service/DoD control over the program. (Blanchard,1990,p.23)

b. Acquisition Management System

The acquisition management system is designed to provide for a streamlined acquisition management structure and an event-driven acquisition process that explicitly links milestone decisions to demonstrated accomplishments. This process provides the basis for making informed trade-off

decisions, given affordability constraints and the user's needs. It also represents the means for translating the user's needs into alternative concepts and, ultimately, a stable system design. (DoDD 5000.1,1991,p.2)

Figure 2 illustrates the sequential nature of this

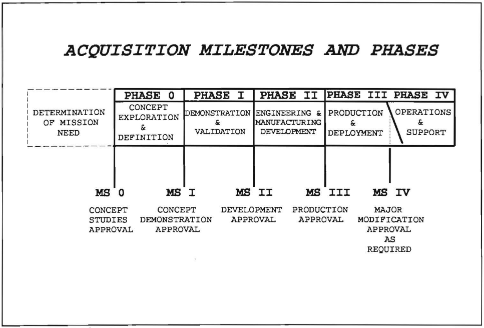

Figure 2 Milestones and Phases

process followed by a "condensed DoDD 5000.1" description of what is entailed within each milestone and phase.

(1) Determination of Mission Need. All acquisition programs are based on identified mission needs. These needs are generated as a direct result of continuing assessments of current and projected capabilities in the context of changing military threats and national defense policy.

(2) Milestone 0 - Concept Studies Approval. Milestone 0 marks the initial formal interface between the requirements generation and the acquisition management system. The milestone decision authority decides what action should be taken on the MNS at this decision point. For those MNS receiving favorable consideration, the milestone decision authority authorizes studies of a minimum set of materiel alternative concepts. A decision to proceed at this point does not establish a new acquisition program. Instead, it merely reflects approval to proceed with studies of alternative concepts that could satisfy the identified mission need.

(3) Phase 0 - Concept Exploration and Definition. Competitive, parallel, short term studies by the Government and/or industry will normally be used during this phase. The focus is on defining and evaluating the feasibility of alternative concepts and providing the basis for assessing the relative merits of the concepts at the Milestone I, Concept Demonstration Approval, decision point. The COEA is most

instrumental in this decision making process and in any subsequent awards to industry.

(4) Milestone I - Concept Demonstration Approval. Milestone decision authorities must assess the affordability of a new acquisition program at Milestone I. This decision marks the first direct interaction between the planning, programming, and budgeting and acquisition management systems. A favorable decision at Milestone I establishes a new acquisition program and a Concept Baseline, containing initial program cost, schedule, and performance objectives for the new program and authorizes entry into Phase I. The program management office will be established and the program manager assigned within 6 months of a favorable decision.

(5) Phase I - Demonstration and Validation. When warranted, multiple design approaches and parallel technologies are pursued within the system concept(s) during this phase. Supportability and manufacturing process design considerations must be integrated into the system design effort early to preclude costly redesign efforts downstream in the process. Prototyping, testing, and early operational assessment of critical systems, subsystems, and components will be emphasized. This is essential to identify and reduce risk as well as assessing if the most promising design approach(es) will operate in the intended operational environment.

(6) Milestone II - Development Approval. The objectives of Milestone II are to determine if the results of Phase I warrant continuation and to assess the affordability of the program by establishing a Development Baseline. This baseline contains refined program costs, schedule, and performance objectives for a program approved for continuation. Establishing the Development Baseline requires effective interaction among the requirements generation, acquisition management, and the planning, programming, and budgeting systems. Development approval will typically involve a commitment to low-rate initial production. The determination of the low-rate initial production quantity to be procured before completion of initial operational test and evaluation shall be made by the milestone decision authority at Milestone II in consultation with the Director, Operational Test and Evaluation.

(7) Phase II - Engineering and Manufacturing Development. The objectives of Phase II are to translate the most promising design approach developed in Phase I into a stable, producible and cost effective system design. This is accomplished by validating the manufacturing or production process and demonstration through testing that the system capabilities, both, meet contract specification requirements, and, satisfies the mission need established in the operational performance requirements.

(8) Milestone III - Production Approval. A favorable decision at this point represents a commitment to build, deploy, and support the system. Milestone decision authorities must confirm the affordability of the proposed program and determine that the materiel item is approved for Service use as part of the production approval process. It must also be ensured that the design is stable and producible and that production processes have been validated so that a realistic Production Baseline can be established. Particular attention must be placed on assessing developmental and operational test and evaluation results, establishing the most economic production rate that can be sustained, identifying the criteria to be used to declare when operational capability is attained, and ensuring that planning for deployment and support is complete and adequate.

(9) Phase III - Production and Deployment. Phase III objectives are to establish a stable, efficient production and support base, achieve an operational capability that satisfies the mission need, and conduct follow-on operational and production verification testing. These tests are designed to confirm system performance and quality and to verify the correction of previously noted deficiencies. The results of field experience to include operational readiness rates will be continuously monitored to assess the ability of the system to perform as intended, identify and incorporate into

production lots minor engineering change proposals, and evaluate the need for major upgrades or modifications that require a Milestone IV, Major Modification Approval, review.

(10) Milestone IV - Major Modification Approval (as required). The objective of Milestone IV is to determine if major upgrades to a system currently in production are warranted, and if so, establish an approved acquisition strategy and baseline (Concept, Development, or Production) for the program. When a system is no longer in production, a deficiency resulting from a change in threat, defense policy, or technology must be defined in a new MNS. The intent is that potential systems modifications should compete with all other possible alternatives during a new Phase 0.

(11) Phase IV - Operations and Support. This phase overlaps with Phase III. It begins after the initial systems have been fielded. The main objectives of Phase IV are to ensure the fielded system continues to provide the capabilities required to meet the identified mission need and to identify shortcomings or deficiencies that must be corrected to improve performance. Quality and safety problems will be corrected as identified during this phase.

c. Planning, Programming & Budgeting System

The Defense Systems Management College's "Introduction to Defense Acquisition Management" describes the Planning, Programming and Budgeting System (PPBS) as:

> The PPBS is the official management system which ultimately produces DoD's portion of the President's budget. It is unique to DoD and was originally introduced to the Department by Secretary of Defense Robert McNamara in 1962. The PPBS is a cyclic process with three distinct but interrelated phases, Planning, Programming and Budgeting. It provides a formal, systematic structure for making decisions on policy, strategy and the development of forces and capabilities to accomplish anticipated missions. The PPBS provides for the time-phased allocation of resources and submission of supporting documentation. Its objective is to provide operational commanders with the best mix of forces and support in view of real fiscal constraints. (Schmoll,1993,p.29)

Until 1986, the PPBS was an annual process through which DoD prepared its annual budget. Beginning in 1987 with the submission of the first 2-year defense budget (for fiscal years 1988-1989), PPBS itself became a biennial procedure. A complete PPBS cycle takes 24 months (February of year 1 to February of year 3). The PPBS also results in periodic updates (at least twice annually) to the Future Years Defense Program (FYDP). The FYDP reflects requirements for the outyears based on DoD planning to meet national defense objectives. A brief description of each of the segments of the Planning, Programming and Budgeting Systems follows.

Planning is the responsibility of the Under Secretary of Defense for Policy. The planning phase is 9 months long, starting in February of each odd-numbered calendar year (the "off year" for programming and budgeting) and ending in October with the publication of the Defense Planning Guide (DPG).

Programming is managed by the Assistant Secretary of Defense for Program Analysis and Evaluation. It is the bridge between planning (with broad fiscal guidance) and budgeting (which meticulously prices each program element). It begins with the issuing of the draft DPG in August of each odd-numbered calendar year and ends with the submission of the service and defense agency Program Objective Memoranda (POMs) in April of each even-numbered calendar year.

Budgeting is the responsibility of the DoD Comptroller. Based on OSD review/comment on the POMs, Budget Estimate Submissions are prepared and forwarded (in September of the even-numbered calendar years) to OSD by the military departments and defense agencies. Service and defense agency budgets are reviewed and the final DoD budget then goes to the Office of Management and Budget (OMB) to be incorporated into the President's budget submission to Congress, thus ending the budgeting phase. (Schmoll,1993,p.30)

C. RDT&E FUNDING

The Research and Development portion of the DoD budget, referred to as Research, Development, Test and Evaluation (RDT&E) constitutes Category 6 of the DoD budget, and is subdivided as follows: Research, 6.1; Exploratory Development, 6.2; Advanced Development, 6.3 (broken down further into 6.3A, advanced development prior to the development of specific systems, and 6.3B which focuses on

specific systems); Engineering Development, 6.4; Management and Support, 6.5; and Operations Systems Development. 6.6. This organization reflects emphasizing a progression from basic research through various stages of development of the final product. New concepts are researched at the 6.1 level, and if proven, advance to the 6.2 level, where the research is applied to a preliminary laboratory device. If the 6.2 criteria are satisfied, the program proceeds to the 6.3 level, where the technology goes through Advanced Technology Demonstrations and/or the demonstration and validation phase. If warranted, during this phase, prototypes are developed for further testing and evaluation. Finally, in 6.4, programs successful in demonstration and validation are redesigned for production, should the need be required. Operational Systems Development funds, 6.6, are used for developing improvements to the system during production phase and after it is fielded. The Management and Support funds, 6.5, cover the overhead activities throughout the R&D process. (Nunno,1992,pg.1)

Figure 3 is a functional view of the RDT&E process in terms of five sequential phases. The first two blocks, Research and Exploratory Development, constitute the Technology Base. Combined with part of the third block, Advanced Technology Development, 6.3A, they represent the DoD and Army Science and Technology effort. The remainder of the third block, 6.3B, by far the larger part of Advanced Development, represents the development effort toward

Demonstration and Validation of concept and system feasibility. The fourth block represents Engineering and Manufacturing Development and Operational Systems leading to the fifth block, Production and Deployment, the fielding of

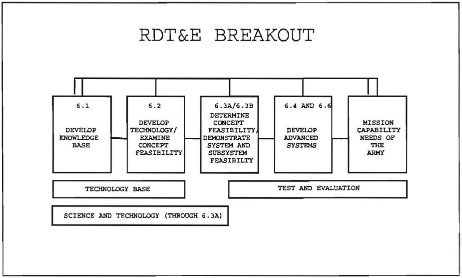

Figure 3 RDT&E Functional Flow

the system to provide mission capability needs of the Army. The lines linking each block emphasize that the RDT&E process is not a simple linear progression, but rather involves much iteration and feedback. (DoN RD&A Guide,1993,Pg.2)

D. ACQUISITION ORGANIZATIONAL STRUCTURE

Another key element to the success or failure of an acquisition strategy is its organizational structure. It is

imperative that each organization be funded, resourced and staffed with the appropriate assets in order to achieve the maximum capability that simulation has to offer. Figure 4 depicts the acquisition related organizations that will be

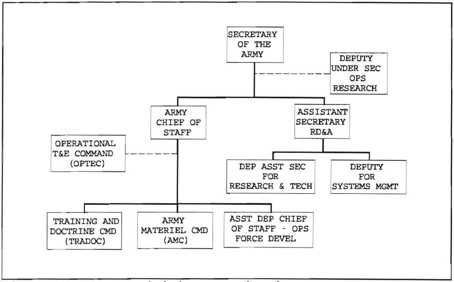

Figure 4 Army Acquisition Organizational Structure

addressed in this document. The basic functions and responsibilities of each will be described in the following paragraphs. In Chapter V these organizations will be analyzed to determine whether the current allocation of assets and resources for these entities support the effective application of modeling and simulation technology.

1. Deputy Under Secretary of the Army (Operations Research) (DUSA(OR))

The DUSA(OR) reports directly to the Secretary of the Army for the following:

- Managing the Army Study Program, the Model Improvement Program, and the Simulation Technology Program.
- Establishing policy for operations research and systems analysis activities for the Department of the Army analytical support services.
- Supporting the Army Systems Acquisition Review Council, Defense Acquisition Board, and similar systems acquisition review committees.
- Providing policy and program direction for the Army Officer Operations Research Education Program.
- Approving test-related documentation for the Department of the Army and forwarding it to the Office of the Secretary of Defense.
- Serving as the principal Department of the Army interface with the Director, Defense Research and Engineering, and the Director, Defense Operational Test and Evaluation.
- Providing policy and oversight for the Army Contracted Advisory and Assistance Services.

2. Assistant Secretary of The Army - Research, Development & Acquisition (ASA(RDA))

The Assistant Secretary of the Army (Research, Development & Acquisition) serves as the Army Acquisition Executive (AAE), the Senior Procurement Executive, the Science Advisor to the Secretary, and serves as the senior research and development official for the Department of the Army. The

ASA(RDA) is responsible to the Secretary of the Army and responsive to the Chief of Staff, Army. The ASA(RDA) is assisted by a Military Deputy (MILDEP) who is also the Director, Acquisition Career Management (DACM).

Some of the major responsibilities that the ASA(RDA) and the AAE have that directly relate to this thesis are:

- Managing the acquisition programs of the Army in accordance with established DoD policies and guidelines.
- Establishing a streamlined acquisition structure for managing Army acquisition programs.
- Designating the Army command or agency responsible for performing system engineering trade-off analyses for the cost and operational effectiveness analysis (COEA), and provide issues, alternatives, and broad guidance for DCSOPS inclusion in the COEA tasking document.
- Reviewing and approving the Army position at each decision milestone before the Defense Acquisition Board (DAB) review.
- Representing the Army on the DAB.
- Developing, implementing, and monitoring the Science and Technology Information Program.
- Developing materiel systems acquisition policy.
- Managing the Army Research, Development, Test and Evaluation, and procurement appropriations.
- Managing the transition from development to production, to include Production Readiness Reviews.

3. Deputy Assistant Secretary for Research and Technology

The Deputy Assistant Secretary for Research and Technology reports directly to the ASA(RDA) and his major responsibilities include:

- Acting as the Army S&T Executive and a member of the Defense S&T Working Group.
- Planning and implementing 6.1 through 6.3A RDT&E expenditures in support of the Army's S&T Base.
- Setting policy and issuing guidance to improve Army Research, Development and Engineering Centers (RDECs) and laboratory management.
- Approving S&T acquisition plans.
- Setting policy and issuing guidance for Independent Research and Development, Small Business Innovative Research and Advanced Concepts Technology Programs.
- Managing the Army Science Board, Army Federally Funded Research and Development Centers, National Academy of Sciences Board on Army Science and Technology.
- Setting policy, priorities, funding and issuing guidance for the Army In-House Laboratory Independent Research.
- Directing the Army Domestic Technology Transfer Program and S&T Information Program

4. Deputy for Systems Management

The Deputy for Systems Management also reports to the ASA(RDA) and is responsible for executive program management oversight and implementation of acquisition policy for aviation, missile, ground combat, intelligence/electronic warfare, and special operations force acquisition programs. He is the direct link between the AAE and assigned program PEOs and provides guidance, assistance, and direction. Much of the Deputy for Systems Management's power and responsibility stems from fact that he controls and implements almost the entire 6.3B through 6.6 RDT&E budget for the Army.

5. Operational Test and Evaluation Command (OPTEC)

The Operational Test and Evaluation Command (OPTEC) was established 15 November 1990 by Secretary of the Army General Orders Number 6. It consists of the OPTEC Headquarters and Support Agencies, the Operational Evaluation Command (OEC) and the Test and Experimentation Command (TEXCOM). The new command consolidates the previous TRADOC Test and Experimentation Command (TEXCOM), the previous Operational Test and Evaluation Agency (OTEA), and the previous Acquisition and Development of Threat Simulators Activity (ADATS-A) into a single command. ADATS-A, renamed the Operational Threat Support Activity (OTSA), and the Test and Evaluation Coordination Offices (TECOs), are incorporated within OPTEC Headquarters. OPTEC's mission is to conduct all user test and evaluation (except medical) for the Army. User T&E includes operational test and evaluation (OT&E) in support of the materiel acquisition process, and force development testing and experimentation (FDTE), concept evaluation program (CEP) trials, and the Army part of joint test and evaluation (JT&E).

OPTEC, Figure 5, is a field operating agency of the Office of the Chief of Staff of the Army. In keeping with the Defense Directives, it reports the results of T&E through the Vice Chief of Staff of the Army directly to the Army and Defense leadership. The main part of OPTEC's mission is the planning, conducting, and reporting of OT&E which has been

required by law since 1972. Additionally, OPTEC conducts tests for TRADOC in support of its mission to develop combat

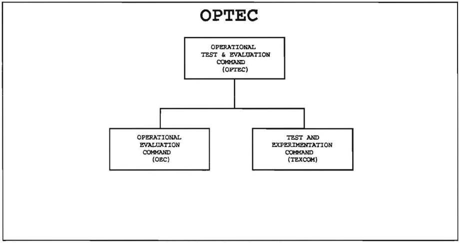

Figure 5 OPTEC Organizational Structure

doctrine, organizations, and materiel requirements.

6. Army Materiel Command (AMC)

The AMC Regulation 10-2 states that the mission of the Commanding General, AMC, is to:

- Perform assigned materiel and related functions comprising research and development; configuration management; product assurance; test and evaluation; scientific and technical information; integrated logistics support planning and execution; rationalization, standardization, and interoperability; acquisition; product improvement; industrial preparedness; production; maintenance; wholesale materiel requirements determination; packaging; and disposal.
- Develop and provide, in response to the objectives and specific requirements established by the user community, materiel and related logistic services.

* Command subordinate commands, installations and activities as assigned (Those entities that impact this thesis will be detailed below).

* Provide worldwide technical and professional guidance and assistance for planning and conducting logistics support of Army materiel.

Figure 6 depicts the AMC subordinate units mentioned in bullet number 3.

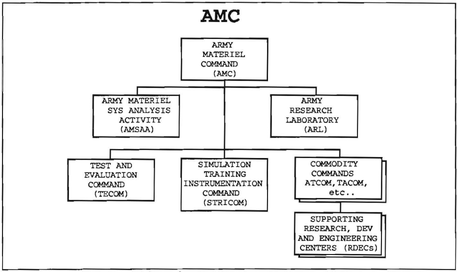

Figure 6 AMC Organizational Structure

a. Army Materiel Systems Analysis Activity (AMSAA)

AMSAA is the systems analysis and modeling activity reporting to the AMC Commander. As the independent developmental evaluator for Army materiel systems, AMSAA's responsibilities include participating in the concept exploration process by performing the following:

- Evaluates all materiel acquisition programs and deployed systems.
- Performs integrated logistic support program surveillance for Army materiel systems.
- Conducts risk analysis.
- Prepares the developmental T&E portion of the TEMP in conjunction with the developmental tester.
- Analyzes and evaluates developmental test data.
- Conducts advanced technology demonstrations in assigned areas.

b. Army Research Laboratory (ARL)

ARL is a new organization within AMC which consists of the seven laboratories which made up the former Army Laboratory Command. It combines the laboratories with additional selected technical base activities from other organizations within the Army. The ARL is responsible for overseeing and managing nearly 75 percent of the Army's technology base program. Its primary area of operation resides in the 6.1 and 6.2 areas of the RDT&E budget for technology development. The commanding officer of ARL reports to the commander of AMC. (Davey,1991,p.15)

c. Test and Evaluation Command (TECOM)

TECOM is responsible to all subordinate agencies throughout AMC for the support, assistance, and oversight of developmental test and evaluation for each acquisition program.

d. Simulation, Training and Instrumentation Command (STRICOM)

STRICOM, in addition to procuring simulators is the Army's technical agent for Distributed Interactive Simulation (DIS) development and network management. This includes the Battlefield Distributed Simulation - Developmental (BDS-D) network.

e. Commodity Commands

Commodity Commands house the program executive officers and program managers responsible for the design, procurement, sustainment, and retirement for systems such as helicopters, tanks, missiles, etc... Examples of commodity commands are the Aviation and Troop Command, ATCOM; the Tank and Automotive Command, TACOM; and the Missile Command, MICOM.

f. Research, Development and Engineering Centers (RDECs)

RDECs provide engineering support for production, systems and weapons improvement. They are responsible for technology demonstration and engineering and development activities that are system related. The centers are oriented toward the development of technology programs, leading to products and systems. These centers are the engineering arms of the Army's commodity commands. (Davey,1991,p.6)

7. Training and Doctrine Command (TRADOC)

TRADOC, Figure 7, is the Army's principal doctrine

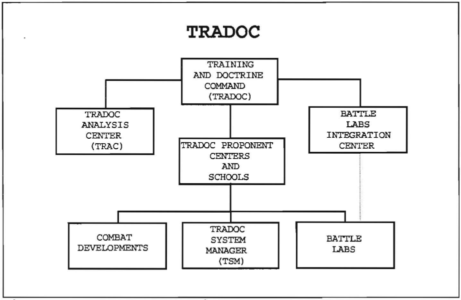

Figure 7 TRADOC Organizational Structure

developer, combat developer, training developer, and trainer. TRADOC:

- Represents the user during all aspects of requirement definition, system acquisition, and force development.
- Defines Army organizational, leader development, training, and materiel operational requirements.
- Analyzes and projects the future threat in coordination with other appropriate Army and DoD organizations.

The acquisition related TRADOC activities that will be addressed in this thesis are illustrated above.

a. TRADOC Analysis Center (TRAC)

TRAC performs applied and developmental research in selected topical areas to advance Army warfighting doctrine and analysis; leverage investments by the Advanced Research Projects Agency, OPTEC, Army Research Institute, and other government organizations into TRAC, TRADOC, and the Army.

b. TRADOC Proponent Centers and Schools

TRADOC proponent centers and schools represent the individual branches within the Army (Aviation, Infantry, Transportation, etc..) in identifying, and recommending solutions for, mission need and mission area deficiencies. They prepare and execute the required training that is unique for their particular branch and submit long-range modernization plans through TRADOC to the Assistant Deputy Chief of Staff - Force Development for prioritization within the Army in support of the Program Objective Memorandum.

(1) Combat Developments. Combat Developments is the user's organization that performs the studies, analysis, and support required to identify, and provide solutions for, mission need and mission area deficiencies. Combat developments are generally comprised of the following divisions to contribute to these efforts: concepts and studies; simulations and scenarios; organization and force development; and materiel, logistics and support.

(2) TRADOC System Manager (TSM). The TSM is the branch and user's representative for a particular system responsible for dealing with all branch external entities to include the system program manager's office, industry, Department of the Army and DoD staffs, and Congress. The TSM is the equivalent rank as their program manager counterpart. The TSM office is located at the appropriate proponent center.

c. Battle Labs

The Battle Lab network is illustrated in Figure 8.

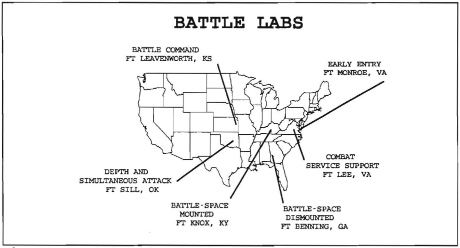

Figure 8 Battle Lab Network

Its concept and progress to date are covered in detail in Chapter IV, Section C.

8. Assistant Deputy Chief of Staff for Operations - Force Development (ADCSOPS-FD)

The ADCSOPS-FD consolidates the individual system prioritization request of each branch of the Army and generates a master prioritization list for the Army as a whole. This priority list is used for selecting the Army's "silver bullets" in terms of funding and Congressional support. He must work closely with the Deputy Assistant Secretary for Research and Technology and the Deputy for Systems Management to ensure his actions are in concert with the ongoing developments in the RDT&E structure.

IV. TECHNOLOGY INFRASTRUCTURE

A. GENERAL

The Army, through TRADOC, is developing "Battle Labs" at its primary combat development laboratories. Additionally, the Army is intent on integrating operationally oriented "virtual" simulation networks with high resolution "constructive" models. The potential advantages of integrating these simulation capabilities throughout the acquisition process are numerous, but limited mainly by the Army's ability to understand, access and integrate these emerging technologies.

This chapter defines these simulation and modeling technologies, introduces the Army's Battle Lab Network, and illustrates how the Chief of Staff of the Army plans to exploit this M&S capability through a series of virtual exercises called Louisiana Maneuvers.

B. TECHNOLOGY STRATEGY

The Army's mission is power projection in defense of national interest. The necessary reshaping of the Army, in the face of reductions in dollars and people, requires a new reliance on technology and a new technology strategy. This strategy is based on a decrease in large procurements and an

increase in upgrades of existing systems by inserting new technology. (Battle Labs Guide(BLG),1993,p.2)

The Army technology strategy includes pursuing the most cost effective advanced technologies to ensure the technological edge. Simultaneously, cycle time from laboratory to production must be reduced; otherwise the advantage of developing a leading edge technology is jeopardized. Distributed Interactive Simulation and Advanced Technology Demonstrations will be used extensively to improve the definition of weapon system requirements. (Vaden,1993,p.8)

Experience shows that, at the transition from technology development to the engineering and manufacturing development phase, at milestone II, only about 10 percent of the system's life cycle cost have been spent. However, at milestone II, decisions have been made that predetermine as much as 90 percent of the system's life cycle costs. The recently-developed Battle Lab concept is designed to provide hands-on user involvement during this highly leveraged early part of the acquisition process. Better early planning and requirements definition, through M&S, will result in both more effective systems and lower life cycle costs. (BLG,1992,p.2)

From a military perspective, anything short of war is a type of simulation. Simulation for the Army refers to one (or a combination of) the following three types:

1. "live" simulation, i.e., operations with real equipment in the field

2. "constructive" simulation which deals with wargames, models and analytical tools

3. "virtual" simulation refers to systems and troops in simulators on synthetic battlefields (Singley,1993,p.35).

Technological pieces that may make up this simulation capability include a Distributed Interactive Simulation environment transmitted over the Defense Simulation Internet communications network linking Janus, a high resolution "constructive" model, Semi-automated forces, and the Battlefield Distributed Simulation - Developmental "virtual" simulator complex. Janus and Battlefield Distributed Simulation - Developmental are by no means the only constructive and virtual models available to the Army. However, for the purpose of this document they provide excellent examples of the potential simulation capabilities currently pursued by the Army.

1. Distributed Interactive Simulation and Protocol Data Units

One of the main challenges to date is the attempt to integrate constructive and virtual simulation technologies. This is an ominous task, considering that these dissimilar computers and simulators that the Army wants to combine into one integrated network weren't initially designed to communicate with one another. To achieve this desired,

seamless simulation capability requires a simulated environment that provides a common definition of standard terms, or protocols that will allow these different computers and simulators to communicate. This common definition of standard terms is achieved by Distributed Interactive Simulation (DIS) Protocol Data Units (PDUs).

DIS creates a synthetic environment within which humans may interact through simulation at multiple, networked sites using compliant architecture, modeling, protocols, standards, and data bases. DIS and its PDUs are the next generation of distributed simulation evolving from the Advanced Research Project Agency's (ARPA) research project of the 1980's known as Simulation Network (SIMNET). However, DIS is barely in its initial stages with many obstacles yet to be tackled. (IST,1993,p.4)

DIS will take advantage of currently installed and future simulations manufactured by different organizations. Consequently, a means must be found for assuring interoperability between dissimilar simulations. The first step in achieving this interoperability is to develop a communications protocol. There must be an agreed-upon set of messages that communicate between host computers, the states of simulated and real entities, and their interactions. This information is communicated through DIS PDUs. (IST,1993,p.8)

2. Simulation Standardization

The current work on simulation standards began in August 1989 with the first workshop on Standards for the Interoperability of Defense Simulations. A second workshop took place in January 1990. As a result of these workshops and subsequent subgroup meetings, over 150 position papers containing recommendations for the standard were submitted to the Institute for Simulation and Training (IST).

Using SIMNET as a baseline IST developed a first draft for a military standard which describes the form and types of messages to be exchanged between simulated entities in a DIS. A third workshop was conducted in August 1990 in which industry and Government provided feedback on the proposed standard. The final draft standard was submitted in January 1991 and approved minor changes, which have been incorporated by the IST. This document has been submitted to the Institute of Electrical and Electronic Engineers (IEEE) to become the IEEE standard. (IST,1993,p.9)

Initial capability for implementing the end-state architecture has been established through the approval of IEEE Standard 1278, in March 1993, for DIS data exchange protocols for interconnecting constructive simulations. The Army is currently leading industry and the other Services in the development of the DIS architecture. Achievement of full end-state capabilities will require continued work through near- and mid-term periods. (DIS MODPLAN,1993,p.4)

3. Defense Simulation Internet

DIS operations are supported by a communication system known as the Defense Simulation Internet (DSI). This communication system was developed, and is currently operated by Advanced Research Projects Agency. The DSI consists of long-haul commercial telephone circuits over AT&T with nodes at the users' home stations, and strategically placed "switching nodes" ("Fix East and Fix West") with a central controlling facility in Chicago, IL. Connectivity is made to military and civilian satellites to allow worldwide, simultaneous DIS operations. (DIS MODPLAN,1993,p.2)

Presently, there are approximately thirty DSI nodes supporting all Services' command posts, Battle Simulation Centers, test beds, Battle Labs, research centers, unified commands, and civilian companies that support the military. The DSI is expected to expand over the next year with approximately 25 additional sites. (DIS MODPLAN,1993,p.2)

Each location physically connected to the DSI network is referred to as a "DSI node." At present, the Army operates two TRADOC Battle Lab nodes on the DSI; Fort Knox and Fort Rucker (Fort Rucker has been designated a Battle Lab support facility). Eventually the Army wishes to have six to eight Army Battle Lab nodes and additional communications-only nodes to most major commands throughout the Army. (Singley,1993,p.37)

Through the interperative capabilities of DIS and the communication network established by the DSI the Army will attempt to build its future by linking constructive models such as Janus with virtual simulation networks such as BDS-D.

4. Janus

Janus is a computer-based, two-sided combat simulation model named for the two-faced Roman god of the portals, who was able to look in two directions simultaneously. Janus UNIX 3.17, and Janus Virtual Memory System (VMS) 4.0, are the most recent versions of the model that are now in common use. (Pate,1992,p.2)

The Janus combat model accommodates up to 600 individual combat systems (including up to 100 indirect fire systems) per side, all moving, detecting, and firing over a 50 kilometer^2, three-dimensional terrain representation. Combat systems (e.g., tanks, helicopters, dismounted infantry, etc.) are defined by the measured attributes of the real or notional systems being modeled (e.g., size, speed, sensor(s), armament, armor protection, thermal/optical contrast, etc.). The vulnerability of each system is characterized by data sets of probability of hit (P_H) and probability of kill (P_K) that individually associate each combat system with each weapon in the simulation. (Crooks,1992)

Janus, because of its high resolution capabilities, has been used predominately in aiding analysts in Cost and

Operational Effectiveness Analysis (COEA) and combat development system studies. It wasn't until recently that the concept of trying to integrate a constructive model with a virtual simulation environment was acted upon. Currently, one of the main thrusts of the Anti-Armor Advanced Technology Demonstration study is to merge constructive and virtual simulation worlds. This allows the orchestration of selected forces, within the virtual simulation environment, to be controlled from a constructive model such as Janus. This is referred to as semi-automated forces.

5. Semi-Automated Forces

To keep costs associated with experiments within budgetary constraints, Semi-Automated Forces (SAFOR) can be used to represent both friendly (adjacent, supporting, and higher and lower formations) and threat forces. The SAFOR capability allows a single individual sitting at a constructive model to control various sized units such as platoons, companies, or battalions within a virtual simulation. These forces appear on the virtual battlefield just as manned simulators do; the fact that they are SAFOR is transparent to the other players. (Loral,1992,p.2)

SAFOR is desirable from both a command and control and a costs savings perspective. Command and control is enhanced by the capability to control several systems on the virtual battlefield from a constructive model. Savings are derived

from constructive models that generate a system on the virtual battlefield much cheaper than virtual networks such as BDS-D.

6. Battlefield Distributed Simulation - Developmental

The intent of M&S integration into the acquisition process is to simulate before you build, buy, and fight. BDS-D provides a "virtual" battlefield on which individuals can fight and analyze the effectiveness "deltas" resulting from the changes made in equipment, doctrine, tactics, organizations, and training methods. The sequence of the battle can be recorded and later analyzed in detail to refine those changes.

This technology creates a simulated or, "virtual", battlefield on which users can conduct cost-effective experiments or exercises. The exercises are conducted using actual soldiers operating the simulators, thus permitting soldier-in-the-loop experimentation. Through a combination of local area and long haul networks (DSI), soldiers operating simulators at one site are able to see and interact with soldiers operating at other sites on a common digitized battlefield. (Loral,1992,p.3)

The Battlefield Distributed Simulation - Developmental (BDS-D) program is sponsored by the U.S. Army. The Commander, US Army Simulation, Training, and Instrumentation Command (STRICOM) is the Program Manager for the BDS-D effort.

STRICOM provides the focal point between DoD agencies, user agencies, industry, and the BDS-D sites. (Loral,1992,p.4)

BDS-D in general will support experiments and evaluations in a variety of areas. Using the approach of simulating before and during the building and/or buying of a new weapon system, users are able to experiment with the design of a new or improved weapon system throughout its acquisition life cycle. For example, researchers can perform the following:

- Define requirements accurately and assess trade-offs.
- Explore the capabilities that should be incorporated into a new or existing system.
- Investigate the numbers and allocation of the system that achieves optimum performance on the battlefield.
- Determine the best means to employ the system once it is built (Loral,1992,p.4).

The answers to issues such as these are important considerations to a program manager. Similarly, users can experiment with new and innovative ways of employing weapon systems so that they better realize their design capabilities. Changes in organizational structure can also be analyzed to determine the relative effectiveness on the battlefield of competing organizations. (Loral,1992,p.4)

Facilitating this ambitious undertaking requires the development of local area networks consisting of low cost battlefield simulators, and simulations of experimental and

high fidelity systems and SAFOR. These simulators will all be linked together via DSI to provide virtual combat operations in the DIS environment for materiel and combat development, and operational testing exercises. (Kelly,1993,p.19)

C. BATTLE LABS

TRADOC has organized six Battle Labs to identify, develop and experiment with new warfighting concepts and new capabilities offered by emerging technologies. This initiative is a response to the unpredictability of the world situation, where a rapidly-changing array of direct and indirect challenges have replaced the single well-defined threat which drove doctrine and materiel requirements during the cold-war era. (BLG,1993,p.3)

Battle Labs are focal points for examining the latest concepts of battlefield organization, tactics, doctrine and technological capabilities. They facilitate the flow of new ideas and are closely linked with the technology centers of both the Army and industry. Battle Labs experiment with new ideas, examine battlefield dynamics and capabilities offered by new technologies for their impact on the battlefield of the future, and integrate promising concepts across the Army. (BLG,1993,p.3)

Battle Labs will be linked through the DSI to each other, the Army R&D Community, sister Services, DoD, and national agencies. All are organizing to take advantage of the DIS

technology, which was not available to earlier test-bed operations. BDS-D networks will allow experts at the relevant TRADOC Centers - the people who think, write and teach warfighting - to advance ideas and test them by simulation synergistically at a number of locations. (BLG,1993,p.4)

Battle Labs will provide the tools and standards to simulate activities at a high level of realism, from theaters of war to factories and manufacturing processes. To date, the mechanism for entry into the synthetic battlefields has been through a few netted simulators and individual workstations. These will be greatly expanded in the 1990s to include the reconfigurable BDS-D simulators that will provide mixes of real ranges, virtual simulations and aggregated constructions - wargame representations. Multipurpose surrogates, such as SAFOR supported by computer emulation, will allow soldiers to participate or to be simulated in battles, as appropriate. (BLG,1993,p.6)

Simulation tools and methodologies housed by Battle Labs offer industry a new area of innovative development that has potential far beyond its military application. Of particular interest is the use of concurrent engineering principles to reduce development time and speed the acquisition process. Virtual prototypes will be produced, so design and manufacturing tradeoffs can be evaluated. Eventually the manufacturing process, the military system, and the system's

performance may all be modeled and refined before the first piece of hardware is built. (BLG,1993,p.6)

Synthetic environments will not completely replace hardware demonstrations as a means of introducing new capabilities to the user. However, given the increased costs of hardware development and test, contrasted with the decreased costs and increasing fidelity of reconfigurable simulators, the emphasis will certainly shift over time. (BLG,1993,p.7)

Battle Labs will help prepare the Army for the challenges of the next century. Unlike the manpower-intensive Louisiana Maneuvers of the 1940s, simulation and Battle Labs will afford a basis for the Louisiana Maneuvers of the 1990s and beyond. (Ross,1993,p.18)

D. LOUISIANA MANEUVERS

The term Louisiana Maneuvers (LAM) refers to the large-scale military exercises carried out by Army General George Marshall in the pine forest of Louisiana in 1941 to prepare the fledgling American Army for combat in World War II. Today's version of the maneuvers is intended to help prepare the Army to fight battles beyond the year 2000. (Holzer,1993,p.36)

Relying heavily upon simulation and modeling technologies, senior Army leaders will use LAM as a tool to help save money by speeding the introduction of promising new weapon systems.

This is derived from quickly weeding out unworkable concepts, aiding in the development of new doctrine and generally guiding the Army as it reshapes itself for meeting post cold-war missions. (Holzer,1993,p.36)

To accomplish this goal the Army intends to rely upon LAM exercises that allow the Service to consider alternative types of weapons. According to Army Chief of Staff General Gordon Sullivan;

> You need to know that we will use simulation techniques throughout the Army's acquisition process. We will determine needs in large-scale, simulation-supported exercises that allow us to consider alternative solutions that meet our needs. We will use drawings, diagrams and 3-dimensional models generated by computers, put them in constructive or virtual environments, and compare alternatives both technically and tactically.
>
> The most promising technologies will be tested by real soldiers, first in reconfigurable crew stations (BDS-D), then in full scale simulations (LAM). Final designs, production and assembly steps will also be simulated in virtual factories before actual prototypes are made. Then the actual and virtual prototypes will be exercised simultaneously to discover potential problems before production begins. Tactics, techniques, and procedures are also developed along with the system so that the system is fully ready for use when produced. (Sullivan,1993)

President Clinton, in his State of the Union Address, vowed that the men and women who serve under the American flag will be the best trained, best equipped, best prepared fighting force in the world. The current leadership of the Army is intent on using LAM - conducted by the Battle Labs,

exploiting technologies such as DIS, DSI, Janus, SAFOR, and BDS-D - as their vehicle to sustain such a force.

V. ANALYSIS

A. INTRODUCTION

This chapter contains analysis of identified shortcomings in the Army's current acquisition structure to ascertain whether or not M&S can enhance the process. The hypothesis is that modeling and simulation can provide the underlying foundation for the forthcoming acquisition revolution.

Analysis will be conducted in the form of an Acquisition Programmatics Appraisal, in Section B; an evaluation of the Army's Organizational Mission Posture, Section C; followed by an Army Acquisition Modeling and Simulation Assessment, Section D. Section E provides an Analysis Summary to lend continuity for the Conclusions and Recommendations that follow in Chapter VI.

B. ACQUISITION PROGRAMMATICS APPRAISAL

Kaoru Ishikawa, one of Japan's leading experts in quality assurance declares that "no amount of inspection or process control can compensate for an inferior design" (Ishikawa, 1985,p.77).

Yet, the conclusions from the GAO report on acquisition reform state that the major problem in the acquisition process is the lack of new product requirements definition to facilitate a comprehensive design. What is it about DoD's

acquisition process that keeps leading us down a continuous path of poor product performance coupled with cost and schedule overruns? Ms. Preston, the Deputy Under Secretary of Defense for Acquisition reform states:

> We have today an acquisition system that evolved through the adoption of a myriad of rules, regulations, and laws that were intended to address a particular problem or public interest. The combined net effect of those rules, regulations, and laws is a system whose costs exceed any demonstrable benefit. (Preston,1993,p.3)

Former ASA(RDA) Stephen Conver illustrated the monetary impact of Ms. Preston's assessment in saying that, "Between 60 to 70 cents of our acquisition dollar goes to process cost and only 40 to 30 cents towards the product. We owe the taxpayers more for their dollar". (Conver,1992)

The Comptroller General of the United States asks:

> Why, with an increased emphasis on sound development and testing of weapons, do we still witness major commitments to programs, such as the B-2 bomber and the Airborne Self-Protection Jammer, without first demonstrating the system will meet critical performance requirements? Why, with improved cost-estimating policies and procedures, do we still see the unit costs of weapon systems such as the C-17 transport doubling? Why, with the increased emphasis on developing systems that can be efficiently produced and supported, do we have weapons such as the Advanced Cruise Missile and Apache Helicopter, that encounter costly production and support problems? (GAO,1992,pg.1)

Secretary of Defense Perry states that the acquisition process is flawed in fundamental ways. "It's flawed at the very beginning in determining the so-called requirements of a

system, in that it deliberately isolates the requirements process from technical and program realities" (Perry,1987).

What Mr. Perry is referring to is the Research and Advanced Technology portion of the acquisition cycle. The user generally develops the system's Operational Requirements Document during Phase 0 of the acquisition cycle, independent of both program management and industry. If the concept successfully passes the Defense Acquisition Board (DAB) at MS I, then and only then, is a program manager's office established to further develop the system. This represents a major transfer of responsibility and data from the combat developer (user), having defined the operational requirements of the system, to the materiel developer (AMC and program manager) who further develop the concept through Phase I and beyond.

It is at this point, Phase I, that design approaches and parallel technologies are pursued within the system concept. Supportability and manufacturing process design considerations are to be integrated into the system design effort early to preclude costly redesign efforts downstream in the process. Prototyping, testing, and early operational assessment of critical systems, subsystems, and components will be emphasized to insure that the system will function as required in its operational environment. If all proves successful then the system is given approval by the DAB at MS II for development approval.

Is the above described process meeting our current procurement needs? If the acquisition process is still functioning efficiently as some still suggest why do we keep coming back to questions along the lines of the Comptroller General? The research conducted on acquisition programmatics identified, and analyzed, the following four areas:

- Lack of integration among acquisition participants.
- Inadequate knowledge within the Army in the potential, and application, of computer and M&S technologies.
- Improper acquisition cost allocation and funding.
- Difficulty with technology transfer from concept to production.

1. Lack of Integration Among Acquisition Participants

Chapter III, Section B, illustrates how the current acquisition process is both segregated and sequential. The decision making support system depicted in Figure 9 is indicative of this segregate nature. The Venn diagram shows the requirements process interfacing with acquisition management, and acquisition management interfacing with the PPBS and so forth. Figure 9 focuses on the middle of the Venn diagram, where the concurrent integration of R&D should take place. This is not addressed in the DoD 5000.1.

Filling this integration void will require a facility to house both the personnel and M&S assets required to conduct R&D in an integrated fashion. (Ferguson,1993)

General Franks, Commander of TRADOC, realized this requirement when he established the six Battle Labs under his

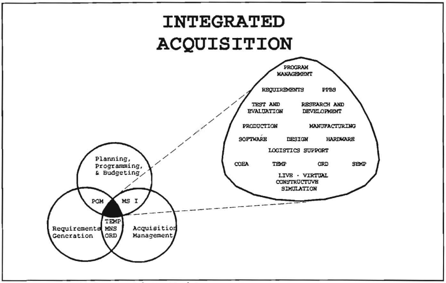

Figure 9 Integration Void

command. The value of Battle Labs is explained by Dr. George Singley, the Army's Deputy Assistant Secretary for Research and Technology;

> In the past we've had engineers and scientist in our labs and centers who knew a particular technology as well as anyone in industry who was leading in that area of research. But in most cases, they didn't have a good feel for what the impact of technology would be in terms of operational capability, or at least be able to articulate it. On the other side, we've had combat development organizations who thoroughly understood combat developments, but who had not spent much time in the acquisition community or in the laboratories. So you had a gap in terms of knowledge, skills, abilities, and vision. The Battle Labs are an opportunity to integrate these folks, along with industry, and allow them to

> iterate in a constructive environment. A fully developed Battle Lab concept will undoubtedly shorten the front end of the acquisition cycle. Computer simulations alone, to say nothing of enhanced cooperation among the various labs, combat arms, and industry, will allow for quicker, more effective trade-off studies. The result will be clearer requirements in less time. (Slear,1992,pg.6)

With Dr. Singley controlling the 6.1-6.3A RDT&E funding for the Army, such statements lend the needed support to get this innovative and integrated approach established within the Battle Labs and the Army as a whole. With respect to requirements generation it appears no other agency or command within the Army has the potential that can rival that of the Battle Labs. If integrated acquisition is the way of the future, Battle Labs, and its simulation capabilities, have the highest probability of success for integrating the required entities of the requirements generation process.

2. Inadequate Computer Fundamentals Within the Army

Computer systems are becoming a predominant part of our major weapon systems. But the requisite knowledge of how to manage and develop these high-tech systems has yet to be established. This is particularly the case for the software of a system. In his address to the acquisition students at the Naval Postgraduate School, Major General Dewitt T. Irby, Program Executive Officer for Army Aviation Systems claimed, "Show me a program in trouble and I'll show a program with software problems" (Irby,1993).

Although software is critical to successfully meeting the cost, schedule, and performance objectives of major defense programs, the defense acquisition community has perceived software as secondary to hardware and as a lower priority during development. Viewing software as something that can be fixed later, program managers generally have not become involved in software development until software problems affect a system's cost, performance, or schedule; usually just before or during operational testing. Because DoD has not effectively balanced the hardware and software requirements of defense systems during development, software is generally immature when certified as ready for operational testing. (GAO,1993,p.4)

During the period 1986 to 1989, over 90 percent of delays in Army Initial Operational Test were the result of embedded software which was not yet able to support system functions (Paul,1992,p.40). In 1989 the Army established the Software Test & Evaluation Panel (STEP) to address the problem of delays in Army system operational test caused by immature software. STEP attributes this phenomenon to the following:

> Various studies have shown that most errors in operational software programs are caused by incorrect or ambiguous statements of requirements for the target system and user. Most of the errors exhibited in fielded software can be traced not to actual engineering defects, but to programmer's misunderstanding of the system and user requirements. STEP has proposed to reduce the number of these software errors through improved procedures to define user requirements for Army software products. (Paul,1992,p.41)

The Army must educate its personnel with the required computer knowledge to establish a base of computer skills that will preclude such errors in the future. Without this knowledge the Army appears to keep repeating such mistakes.

In his article "Software Crisis - Is It a Matter of Guts Management?" Robert L. Glass contends that programs that are managed by people lacking in hardware/software fundamentals are doomed for problems. Glass states;

> We simply do a bad job of estimating how long it will take to build software. It is obvious that poor estimation of requirements will cause poor cost and schedule performance. We can't meet schedule and budget goals because we are working to estimates that were never valid to begin with. But what about unreliability? I would assert that troubled software projects, finding themselves badly behind schedule skimp on testing and release buggy software because it is their only hope of catching up. (Glass,1993,p.27)

As the knowledge regarding computer technology increases, appropriate applications of M&S technologies can produce the level of requirements definition in system software that will generate realistic cost, performance and schedule baselines prior to the start of Phase II. A true commitment to educating the appropriate personnel is a must if progress in software requirements is to be made.

3. Improper Acquisition Cost Allocation and Funding

a. Cost Allocation

The early part of the requirements definition and acquisition process is highly leveraged. This is where M&S can make major impacts in optimizing and streamlining systems procurement. Experience shows that, at the transition from technology development to MS II, only about 10 percent of the system's life cycle cost has been spent. However, decisions have been made that predetermine the remaining 90 percent of the system's life cycle cost (Figure 10). (BLG,1993,p.2)

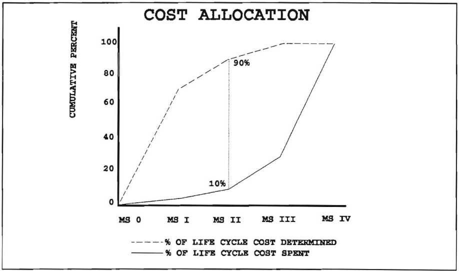

Figure 10 Cost Allocation

It is the contention of this thesis that M&S can make the most dramatic impact in this highly leveraged early part of the acquisition process by affording a greater

capability to define requirements and determine costs. Through M&S more R&D answers can be obtained in the critical first 10 percent which will more accurately analyze and forecast the cost and performance factors for the remaining 90 percent.

An example that displays this leveraging potential involves battle tank prototypes. In 1984, evaluations of possible improvements on the M1 Abrams tank were carried out by using real tanks in a live environment. The effort took 24 months and cost $40 million. A later effort in 1986 used a modified aircraft dome simulator, took only six months and cost $1 million. In 1992, using DIS four variations of the M1 Abrams were operated against potential threats, taking only three months and costing $640,000. (Berry,1992)

Yet this portion of the acquisition cycle has historically been hurried through and underfunded in attempts to get a production commitment from Congress.

GAO's recent report on weapons acquisition reinforces this assertion by stating;

> As a program proceeds through development, the disposition for sponsors to present program information optimistically and to protect the program against disruption intensifies. This behavior is necessary to overcome the numerous challenges a program faces as it commands increasing funds and faces potential criticism. At the same time, program support grows because more acquisition participants have become active sponsors and because the time and money invested have built a compelling argument for continuing the program. Together, these factors compliment the initial efforts to push the program and begin to pull it through the acquisition process. They enable the program

> to develop 'a life of its own' and to become its own objective. Thus, even when the very underpinnings of a program are badly shaken, very strong arguments are made by participants at all levels to continue the program as planned. This is particularly true for programs that have entered the engineering and manufacturing phase (Phase II) by which time it is generally conceded that the programs are committed to production. Ironically, if a weapon has serious problems, these problems are most likely to surface during this phase when the program has become virtually unstoppable. (GAO,1992,p.46)

Traditional problems of cost and schedule overruns coupled with the lack of accurate requirements are still prevalent in the acquisition system. This lends credence to the argument that a redistribution of life cycle cost are in order. It also falls in line with the adage, "we can't afford to build it right the first time but we can afford all the retrofits and modifications stemming from inadequate requirements and an inferior design."

The technological capabilities within our M&S assets can revolutionize the way we conduct the first two phases of the acquisition process. With the aid of M&S, a system can more accurately be evaluated in pre-milestone II efforts thereby reducing the overall cost of a weapon system by more accurately defining requirements and optimizing the design.

b. Funding

Analysis of the RDT&E budget is required to see if the Technology Base will support the M&S analysis in the development portion of the acquisition cycle. The RDT&E

budget is decreasing but is this in the form of vertical cuts to support these emerging M&S technologies? Figure 11 lends pessimism to the prospect of the RDT&E base supporting M&S through the development portion of Program 6 funding.

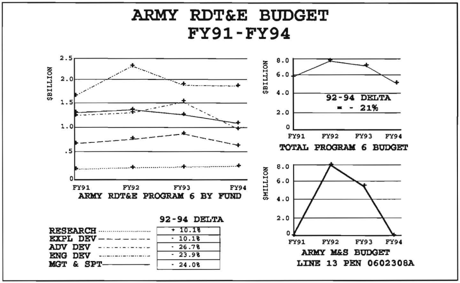

Figure 11 RDT&E Budget FY91-FY94

Exploratory and Advanced Development are the most critical portions of the RDT&E Budget for supporting the requirements generation process. Figure 11 also reveals that both these accounts have declined over the past three years 10.1 and 26.6 percent respectively. Even more indicative of the Army's inability to promote its M&S efforts is the elimination of all funding under the Modeling and Simulation Authorization Line.

The Army has been able to sustain its current M&S efforts by channelling funding from other accounts. This method of financing leads to piecemeal procurements that continue to contribute to the lack of interoperability that currently exists within the Army's M&S assets.

A classic quote from the movie 'The Right Stuff' states, "no bucks no Buck Rogers". The same may hold true for the prospect of a robust M&S architecture. Battle Labs and M&S have been able to obtain funding directly from program managers and other sources but its standing in the FYDP has all but diminished. According to Rear Admiral (Ret.) Milligan, former Budgeting Officer for the Department of the Navy, "Acquiring and maintaining funding in the FYDP requires a great deal of planning and a high degree of gamesmanship. Those who don't survive in the FYDP usually don't survive" (Milligan,1994).

Long term RDT&E funding is critical to procuring the required M&S hardware and software assets. Although way behind the power curve there are some indications that funding relief may be in sight. In the National Defense Authorization Act for FY 1994 the Senate Armed Services Committee recommended the following;

> The committee is pleased by the progress the Army has made in advancing the state-of-the-art in advanced distributed simulation. The Army has demonstrated that simulation can be a valuable tool for enabling the Army Battle Labs to evaluate the military worth of promising technology and new concepts of warfighting. The committee supports the

> Army initiative to involve industry and academia in the Battle Lab simulation process. Given the progress made in this effort and the positive public statements of the senior Army leadership regarding the worth of this program, the committee is perplexed to find that no funding has been budgeted to continue the program. The committee recommends $10.0 million for the program and reduces the funding of other Army programs by the same amount. (SASC,1993,p.68)

It is interesting to note that even at the Senate Armed Services Committee that individuals are perplexed that programs as important as M&S and Battle Labs can be omitted from the budget. There is an error in strategic planning if the Army expects to fully implement the capabilities of M&S and Battle Labs without establishing funding through the appropriate means. For M&S to reach its full potential it must be firmly rooted in the Future Years Defense Plan.

4. Technology Transfer From Concept to Production

The Congress of the United States' Office of Technology Assessment (OTA) proclaimed that in today's technology intensive environment the ability of an organization to compete and win is highly dependent on its ability to discover, develop, and apply advances in science and technology to its systems and products. Success in that endeavor depends, in turn, on the ability of the organization to plan its technology investment strategy, marshal the resources to support it, and build and sustain a technology base vital enough to produce the needed advances. (OTA,1989,p.41)

Continuity of technology transfer from concept to production is a must for an acquisition strategy that is progressive in nature; evolving from S&T, to ATD's, to systems application. This continuity must be established in areas of facilities, personnel and resources, and documentation.

a. Facilities

The research conducted found that the TRADOC Battle Labs offer the Army integrated facilities where combat and materiel developers, industry, and academia may interact on the acquisition process. The evolution of this acquisition process must span across the areas of Basic Research (6.1 funds), Exploration Development (6.2 funds), and Advanced Development (6.3 funds). This span, in terms of facilities and agencies, may typically evolve through the boundaries of the Advanced Research Projects Agency, the Army Research Laboratory (ARL), to the effected branch of the Army, or Battle Labs, for Advanced Development. For Battle Labs to meaningfully contribute the acquisition process in the future, they must have "Basic Research" facilities that can be readily accessed.

The agencies mentioned need not be co-located if they can be interactive for concurrent development efforts. Through DIS, the location of facilities becomes less and less important. If the organization is structured to permit the

necessary exchange of research and support, continuity is maintained as the program evolves.

b. Personnel and Resources

A strong development program must link the S&T personnel to the developers and to the ultimate user of the systems. Senior leaders within the Army interviewed for this thesis pointed to Battle Labs to provide that process continuity. Both General Saint, the former Commander of the U.S. Army Europe, and Lieutenant General Forster, the Military Deputy to the Assistant Secretary of the Army for RD&A, both had strong opinions in favor of the Battle Labs.

General Saint stated;

> The soldier must be brought in from the start and not just as a validation source at the end of the acquisition process. We must start and end our the acquisition cycle based on the needs and inputs from our soldiers and I feel the Battle Labs will contribute significantly in that fashion. (Saint,1993)

While LTG Forster addressed the continuity factor specifically;

> Battle Labs bring the user and buyer together early on in the acquisition process. Before Battle Labs, once the ROC and the RFP were written the combat developer was long forgotten. Now they will remain in the loop to model Pre-Planned Product Improvements and continuing upgrades to the system. This lends continuity to the process that was lost in earlier years. (Forster,1993)

With the promise that Battle Labs display it was interesting to find that the host centers for the Battle Labs

are not allocated any personnel or resources to staff them. Almost all of the personnel within the Battle Labs are transfers from the host center's combat developments. This equates to a very small organic staff for the Battle Labs. "Battle Labs are not resources," insists Colonel Don Kerr, director of the Depth and Simultaneous Attack Lab at Fort Sill, OK. "Our mission is to try to leverage off someone else's work. I only have eight guys here full-time, so we'll be pulling in the experts." (Slear,1992,p.5)

Lack of personnel dedicated to the Battle Labs could prove detrimental to the continuity of the acquisition process if this facility cannot be adequately staffed with qualified personnel. In a zero-gain Army, this equates to these personnel being staffed at the expense of another organization. The research indicated that there was a substantial overlap in the Concepts and Studies, and M&S portions of Combat Developments and Battle Labs. Much can be gained by combining these Combat Developments personnel and resources with Battle Labs.

First, Battle Labs would gain additional resources in terms of personnel, equipment, and funding to support its base of operation. Secondly, Battle Labs, conducting analysis under one of the six battlefield dynamics, will produce a better integrated solution than a parochial laden center. Lastly, it reduces yet another layer of organizational

structure that requires overhead, integration, and support far beyond any demonstrable measure.

c. Documentation

The Office of Technology Assessment found that none of the Services possess a formal written document outlining the prerequisite procedures for successful technology transfer (OTA,1989,p.54). If the Army has an acquisition plan for the efficient evolution of data from basic research to systems application, it is not known by any of the individuals interviewed or found in any source documents. In fact, the only documentation found (OTAs) cites the contrary to any such plan.

Getting a program approved through Milestone I requires a minimum of fourteen major reports, documents, and analysis. For Milestone II the total is nineteen. Attempting to capture the consolidated performance of a program is very difficult in such a myriad of assorted paperwork. Serious reduction of the number of required reports to facilitate the acquisition of a system is in order.

Recent trends show that the number of COEAs performed by the Army is decreasing while the number ATDs is increasing. This is to be expected given the new acquisition strategy focusing on technology demonstrations. How can the research from the ATDs be efficiently incorporated into the required documentation of a system without losing continuity

of the data during the transfer? Having the required documentation of an ATD be aligned with acquisition documents such as the COEA is worth consideration. Or, with the distributed capabilities of computer technology, establish a database account for all research conducted on a specific technology or system. These data can then be accessed when developing the required documentation for a weapon system. This would ensure that all documents and data are contained within the "entire scope of research" enabling full and consistent analysis.

While outside the scope of this thesis a worthwhile endeavor would be to pursue the effectiveness of an enhanced and expanded COEA. With the ability through M&S to make accurate operational effectiveness and cost projections, many current supporting documents could be incorporated into this enhanced COEA to provide more continuity and centralization to the documentation process.

C. ORGANIZATIONAL MISSION POSTURE

For modeling and simulation to be effective the Army organizational structure must acquire, integrate, and support M&S technologies throughout the acquisition community. The major commands within the Army have different primary interests for the use of these technologies and in the means to support them. From an acquisition point of view, these interests may not be supportive of one another.

Organizational mission posture is addressed from the following three perspectives. First, is the optimal mix of M&S resources being acquired by the Army? Secondly, are these M&S resources aligned with the appropriate commands, in terms of mission and support, or can a better alignment of these technologies be made? Lastly, is every organization capable of performing its assigned mission in live, virtual, or constructive simulation environments?

1. M&S Optimization

The Distributive Interactive Simulation Modernization Plan, dated 17 May 1993, asserts that, "everything but combat is simulation" (DIS MODPLAN,1993). This is becoming an ever more popular theme throughout the Department of Defense as researchers and scientists attempt to retain their analytical capability in times of dwindling resources. As the Army transforms into the age of simulation, it must not forget the regulatory and organization frameworks that bind our acquisition process, and the reasons they were originally established. The goal of any acquisition simulation architecture, within the Army, should be to support and streamline the acquisition process; not to circumvent it.

As discussed previously, simulation in the Army is comprised of one, or a combination of, the following three environments: Live Simulation is defined as operations with real troops and equipment in the field; Virtual Simulation

consists of systems and troops in simulators fighting on synthetic battlefields; and Constructive Simulation is the use of wargames, models and analytical tools.

Given the above definitions, if the Army's true philosophy is, "anything but combat is simulation", then the question is not "Do we use simulation?", but rather "What type of simulation do we use?".

Under this philosophy how we procure and test our weapon systems becomes a matter of balancing our simulation assets; a ratio of live, virtual, and constructive environments. This warrants trying to find an optimal ratio between the three simulation environments that will provide the greatest return for the acquisition dollar. Without this prerequisite knowledge of requirements, the fragmented procurement of simulation technologies will most likely fall short of the Army's needs.

The high demand for simulation is being fueled by the decreasing amount of dollars being spent on defense. Live Simulation is very costly but yields a high degree of fidelity and definition in terms of analytical feedback. Virtual Simulation is not nearly as costly (in terms of time, people, equipment, and money) as live simulation but in most cases does not yield the same degree of analytical definition. Constructive Simulation provides a high level of post processed data, at a very low cost, but lacks the man-in-the-loop input to capture more of the humanistic factors of

analysis. The objective now becomes to find an optimal mix between these three environments that will meet the Army's acquisition needs. The solution to this optimization is found in basic economic theory (Figure 12). (Gates,1993)

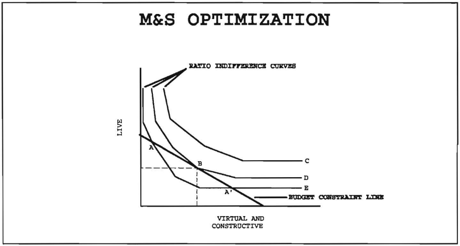

Figure 12 Economic Theory to M&S Optimization

Given the current budgetary constraints facing the Army what combination of these three assets provides the greatest analytical return? The Army can afford to buy combinations at point A or point A', but it can do better. Consider point B, where the ratio is on the highest possible indifference curve (curve D), given our budget constraint. All points on indifference curve C are outside the budget constraint, so the Army cannot afford them. Thus, Point B maximizes our analytical utility subject to the indifference curves (curves D & E) located within the budget constraint.

Note that even on the least costly curve (curve E) that sole reliance on either live or other-than-live simulation may fall outside the Army's available resources.

It appears the Army has neither defined its total simulation requirements, for the appropriate simulation architecture, nor has it established a simulation budget within the Future Years Defense Plan. Individual efforts have been made in the Distributed Interactive Simulation and Battle Lab Master Plans but this does not provide the total requirements necessary when addressing the Army's overall simulation network. The FY 1994 Army RDT&E Budget contains $0.00 under its Modeling and Simulation Authorization Line. Something is amiss.

Without such forecast and preplanning when and how will the Army know when it has the optimum mix of simulation asset? What are the criteria for successful implementation? Procurement without a strategy, implementation plan, or budget leads to fragmented, piecemeal purchases.

Currently, the number of Army M&S programs and proposals far exceed the available resources to support them. For the time being, the Army appears content to acquire its M&S assets in a decentralized manner. For the Army to successfully implement a strategy capable of fulfilling its modeling and simulation needs it should consider doing so under a centralized acquisition plan.

2. M&S Alignment

The physical alignment of M&S assets throughout the Army appears to be very logical. Since the predominant mission of virtual, or BDS-D, simulators is training and acquisition related, one expects to find these assets located at TRADOC installations. The constructive models are dispersed throughout the Army since they are used for anything from combat developments to materiel analysis.

What is surprising is the proponent or ownership relationship of the virtual simulators. All BDS-D simulators are currently positioned at TRADOC installations, under the proponency of AMC, STRICOM, being run by a civilian corporation, Loral. As might be expected this Government Owned - Contractor Operated (GOCO) relationship is not popular among some of the people in the TRADOC community. Loral was facilitating and expeditious in support of this research but some conducting business with them are quite frustrated.

At first glance it would seem to be simple enough to place the control of these virtual assets under the control of TRADOC and the user community. However, the ownership and control of these simulators is quite valued.

With the Army downsizing Major Commands (MACOMs) are laying claim to most anything that will keep them from absorbing further reductions. These simulators are no exception. In fact, many that were interviewed looked at this as a major power struggle between TRADOC, AMC, and the Program

Executive Officers. LTC Bowen stated, "TRADOC is anxious to embrace Battle Labs and BDS-D as a big player because it will shift a major portion of the acquisition policy power to TRADOC. For this very same reason PMs, AMC, and STRICOM, will most likely postulate for status quo" (Bowen,1993). Colonel P.J. Penny, the Director of Simulations at Fort Rucker was a bit more direct, "Battle Labs will fail because PEOs and PMs don't play in the process" (Penny,1993).

Colonel Penny's point is well taken. Most of the analysis done in Battle Labs and BDS-D is in the area of ATDs or requirements generation. This is prior to MS I and the initiation of a program management office.

Modeling and simulation resources need to be responsive to the user because streamlined acquisition is dependent upon a more thorough requirements development process. Therefore, realignment of the control of virtual M&S assets is in order.

3. Mission Capability

Many in the Army are hesitant in the use of simulation. Their concern is that simulation is a poor substitute for live operations or testing. This is a misconception in that virtual or constructive simulation is not intended to replace live operations or testing (live simulation). The attempt is to supplement live simulation with less expensive simulation methods so when performing in

a live environment, less iterations of this costly method are required.

Figure 13 illustrates how variation, throughout the acquisition process, can be reduced through the supplementation of virtual and constructive simulation. This reduction in variation is gained from the ability to test user requirements in virtual and constructive environments prior to production. Decreasing variation in the acquisition process will produce reductions in both cost and schedule while more efficiently meeting the user's requirements.

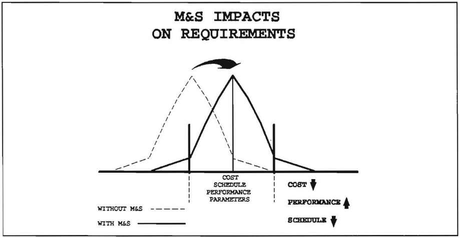

Figure 13 M&S Impacts on Acquisition and Testing

However, the application of M&S generates the question of how organizations within the acquisition community are resourced to perform their missions throughout all three simulation environments.

The development of each weapon system is a cycle of requirements generation, system design, and system production, with testing being an iterative process throughout the cycle. This is depicted in the terms of an acquisition "loop" in Figure 14.

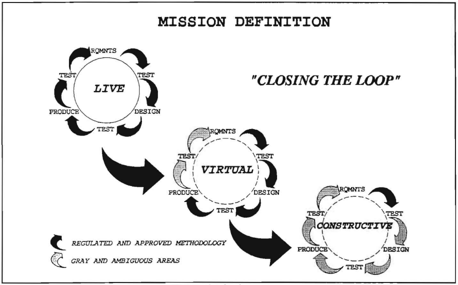

Figure 14 Closing the Acquisition Loop

Acquisition organizations (TRADOC, AMC, and OPTEC) are currently staffed to perform their mission in a "live" simulation environment. This should not be surprising for this is typically the way the Army has conducted business for decades with the exception of the semantical transfer from "live" to "live simulation".

However, as the simulation environment transfers to the "virtual" and "constructive" realms the organizational level of preparedness for some in the acquisition community begins to diminish. It is the independent testing portion of this cycle or "loop" that is most dramatically impacted.

The operational testing community has a most difficult role in defining when, where and how it can participate outside the live environment. Testers find themselves caught between the live fire requirements within Title 10, the United States Code, and the spiral of diminishing defense dollars. This is a most dangerous position.

The Defense Modeling and Simulation Office is funding simulation efforts throughout the Services to test the merits of simulation and operational testing. Data are still insufficient to assess the current ability to utilize other-than-live environments for operational testing. However, it is only a matter of time until technology provides the required simulation fidelity that will make virtual simulation a viable alternative for some early and follow-on portions of operational assessments.

At this juncture, how will the Army's operational testing community be postured to perform its mission? Requirements for independent testing will not vanish simply because of increased transfer from live to virtual environments. Rather, regulatory and organizational requirements should be established for materiel development

under each simulation environment to "close the acquisition loop".

History has proven time and time again that human nature is not capable of overcoming the conflict of interest generated by combat and materiel developers conducting their own operational tests. This should not be forgotten as some senior leaders within Congress and the Army push for the abolishment of the independent tester based on the new found capabilities of simulation.

As the Army moves more and more towards the virtual and constructive environments the merits of independent testing should not be forgotten. There must be an accredited means to accommodate the testing community in virtual and constructive environments. The alternative to traditional independent testing is systems being developed and operationally tested, by the same command, in simulated environments. This conflict of interest must be avoided at all cost. The Army cannot afford to succumb to budgetary pressures by abandoning independent testing in virtual and constructive environments. The foresight of tomorrow's operational testing requirements must be applied, now, if the Army is to successfully operate across the simulation continuum in the future.

D. ACQUISITION MODELING AND SIMULATION ASSESSMENT

Assessing how far the Army has to go to bring this simulation technology to fruition, requires a baseline of current capability. Glenn Conrad, a systems engineer for MITRE Corporation, may have best assessed the Army's current status in converting to the high-tech arena when he stated, "The Army seems intent on trying to impose a management plan on an organization that is not yet resourced to receive it" (Conrad,1993).

Many interviewed attributed the perceived M&S capability that the Army has been given credit for to an extensive media-blitz through military magazines, articles, journals and other such related documents. The fact remains that the Army and DoD are a ways off from harnessing these high-tech capabilities in terms of both technology, and fiscal resources. The media seems to be catching on.

Between June and September of 1992, the Army ran a test called the Synthetic Environment Experiment at Fort Knox, Kentucky. The experiment pitted M1A1 and M1A2 Abrams main battle tanks against a force of "composite" enemy tanks in a series of simulated engagements. There were two main thrusts of the study. One was to compare the combat performance of the M1A1, the Army's premier tank, with that of its successor, the M1A2, which is scheduled to be fielded in December of 1995. The other was to evaluate the usefulness of simulation

technology in improving the acquisition process. (Naylor,1993,p.34)

The Synthetic Environment Experiment failed to show any additional benefit derived from fielding the M1A2 tank. The simulation technology was lacking in sophistication and resolution to replicate fully the modern battlefield and to distinguish the difference between the two versions of the Abrams. This fault is not as important when simulators are used for training, for which BDS-D was originally designed. However, this causes problems in the acquisition process because weapons developers need precise data to design systems and determine if planned improvements will increase combat effectiveness. (Naylor,1993,p.34)

LTC Hardy, the Army project officer for the experiment stated that the Army did not come out of this experiment feeling it had demonstrated M&S was not appropriate for systems evaluation, rather officials now know where they stand, and how far M&S has to go, before it can be of real benefit to the acquisition community. (Naylor,1993,p.34)

Hardy did not predict how much time or money would be required to overcome the technological hurdles currently in the path of the acquisition-oriented simulation. However, LTC Hardy stated, "The Army is developing a master plan, and a modernization plan, which will apply resources to fixing the problems.... To the extent we can apply resources to these

problems and deficiencies, then we'll be able to get where we'd like to go." (Naylor,1993,p.34)

These stated deficiencies have yet to be defined and incorporated into an Army M&S requirement. Acquisition M&S assets are a conglomerate of interdependent technologies. As such, the desired capability of the end product should be addressed as a system. If M&S technologies aren't fielded under centralized procurement, the Army may exhaust its resources before obtaining the desired final product.

In an integrated acquisition environment strategic investments into M&S technologies should support the requirements of the participants. In the Army, this rests within defining mission needs, establishing realistic requirements, and ensuring an accurate design. However, within industry the emphasis is quite different. This contrasting relationship between the Army and industry is illustrated in Figure 15.

Industry M&S participation at the beginning of the acquisition cycle is low. As opposed to the Army, it is not cost effective for industry to invest significant funding until contract award appears imminent. This is reflected in Figure 15 just prior to the MS II timeframe. However, after contract award at MS II, industry M&S efforts start increasing significantly in the form of computer-aided-design, computer-aided-manufacturing, and virtual simulators specifically developed to support the product under development.

Two examples of these simulators are the McDonnell Douglas AH-64 simulator complex in Mesa, Arizona, and the Sikorsky RAH-66 simulator complex in Stratford, Connecticut.

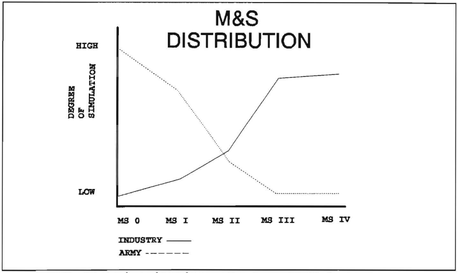

Figure 15 M&S Distribution - Army vs Industry

The AH-64 simulator has been instrumental in the Follow-On Test and Evaluation of the AH-64 and in contributing to the applied technology transfer of the Longbow acquisition system to the aircraft. It makes little sense for the Army to spend additional resources to procure this post-MS II capability with this M&S capability already fielded and under contract.

The above contention is extremely relevant in defining the M&S requirements for the Army. In the case of the Abrams tank it is quite probable that the capabilities that LTC Hardy is

in need of already reside within the capabilities of the contractor for the Abrams.

Acquisition of any M&S assets should be pursued under the auspices of integrated acquisition and dual use technology. M&S requirements definition of the Army should consider the resources residing within all participants of the Army acquisition process. Within this consideration, the most appropriate and beneficial area for the Army to procure organic M&S assets is in the pre-MS II period. Post MS II efforts can be conducted in conjunction with the awarded contractor to preclude the redundant procurement of M&S assets.

E. SUMMARY

Many of the Army's acquisition deficiencies can be overcome by adopting a more integrated approach to acquisition. TRADOC's Battle Labs appear to have the greatest potential for providing the required integrated capability. However, Battle Labs lack the appropriate resources, mainly in terms of personnel and the appropriate funding. If the vision of integrating the Battle Labs throughout the acquisition cycle is to reach fruition, a realignment of Army personnel and funding is a must.

Additionally, organizations within the Army acquisition community must be prepared to function in concert with all three simulation environments. This requires the foresight to

train personnel on the applicable computer skills in conjunction with making regulatory and organizational adjustments to accommodate emerging M&S technologies.

Finally, requirements definition in support of the Army's M&S architecture must be accomplished for the Future Years Defense Plan. This should include the number and type of each asset required to facilitate acquiring a complete M&S architecture. Without this required analysis the Army stands little chance of gaining Congressional support to fund future M&S endeavors.

VI. CONCLUSIONS/RECOMMENDATIONS

A. GENERAL CONCLUSIONS

This thesis focused on whether the Army is postured in terms of policy, technology, funding and organizational structure to advantage the capabilities of current and forthcoming M&S potential. In addition, the DoD 5000 series and the Army acquisition organizational structure were examined to determine whether or not their architecture would house the future methods of conducting acquisition business. The final area of analysis focused on the RDT&E funding levels provided for Army M&S to see if this would afford the realization of the Army's M&S vision.

Modeling and simulation provides the Army with a revolutionary means to enhance the current acquisition process. However, the segregate and sequential structure of the current DoD 5000 series does not fully support the concurrent and integrated requirements for acquisition streamlining. Of major concern is the fact that the Army has yet to establish support for M&S in the RDT&E budget.

Realignment of assets and personnel within the current Army acquisition organizational structure will provide a more capable requirements generation process. Battle Labs are TRADOC's current effort to establish this continuity base for

the requirements generation process. However, Battle Labs lack the authorized personnel and funding required to sustain their progress in the future.

As Army acquisition organizations increasingly transfer to the "virtual" and "constructive" environments, the organizational mission capability for some in the acquisition community begins to diminish. The operational testing community is most dramatically impacted. Testers find themselves caught between the live fire requirements within Title 10, the United States Code, and the spiral of diminishing defense dollars. OPTEC has a most difficult role in defining when, where, and how to participate outside the live environment.

Finally, the number of Army M&S programs and proposals far exceed the available resources to support them. For the time being, the Army appears content to acquire its M&S assets in a decentralized manner.

B. SPECIFIC CONCLUSIONS

The following specific conclusions contribute to the above assessment:

- The current DoD 5000 series is structured for a process that is both segregate and sequential.
- Modeling and simulation assets must be more responsive to the requirements generation process if acquisition streamlining is to be achieved.

- The current 10/90 percent cost allocation, at MS II, does not support an adequate requirements generation process.
- Army M&S potential is most dramatic in the pre-MS II phases.
- Post-MS II efforts can be conducted in conjunction with the awarded contractor to preclude the redundant procurement of M&S assets.
- Required computer knowledge and skills, within the Army, are insufficient to support both the software technology the Army is producing, and, the M&S technology that supports the Army acquisition process.
- Battle Labs lack the authorized personnel and funding required to sustain their progress in the future.
- The Army's Exploratory and Advanced Development Accounts have decreased 10.1 and 26.6 percent respectively. Zero dollars were allotted for M&S in FY 1994. Lack of funding in the RDT&E budget seriously jeopardizes M&S's capability to support the Army acquisition process in the future.
- The degree to which M&S will impact the Army acquisition process is dependent on how well M&S and Battle Labs are represented in the Future Years Defense Plan.

C. RECOMMENDATIONS

Implementation of the following recommendations should enable M&S to impact beneficially on the Army acquisition process:

- **The Concepts and Studies, and M&S sections of Combat Developments should be consolidated with the Battle Lab Network to enhance the Army's requirements generation process.** Battle Labs provide an integrated environment where M&S assets can most beneficially impact the Army acquisition process. Consolidation would provide three major enhancements to the requirements generation process. First, Battle Labs would gain significant resources in terms of personnel, equipment, and funding. Secondly, Battle Labs, conducting analysis under the umbrella of battlefield dynamics, will produce a better integrated

solution than a parochial laden center. Lastly, it reduces yet another layer of organizational structure that requires overhead, integration, and support far beyond any demonstrable measure.

- **Continuity of technology transfer, from concept to production, should be established in terms of documentation.** Research from the ATDs must be efficiently incorporated into the required documentation for a system. Having the required documentation of an ATD align with other acquisition documents, such as the COEA, is essential. Or, establish a consolidated database account for all research conducted on a specific technology or system. These data can then be accessed when developing the required documentation for a weapon system. This would ensure that all documents and data contain the "entire scope of research" and not just fragmented portions; enabling full and consistent analysis.

- **Pursuit of an enhanced and expanded COEA should be initiated.** Through M&S, the ability to make accurate COEA projections dramatically increases. This affords the opportunity to consolidate many current supporting documents into an enhanced COEA to provide more continuity and centralization to the documentation process.

- **The Army should develop a centralized procurement plan that indexes implementation of an acquisition M&S strategy.** This plan should consider increasing M&S efforts, prior to MS II, to enhance requirements generation. In addition to M&S procurement, this plan must consider the personnel training requirements for the use of high technology modeling and simulation assets.

- **The operational testing community should be accredited in virtual and constructive environments.** As the Army increases its efforts in virtual and constructive environments the merits of independent testing should not be forgotten. The alternative to traditional independent testing is a system being developed, and operationally tested, by the same command, in simulated environments. This conflict of interest must be avoided at all cost. The Army cannot afford to succumb to budgetary pressures by abandoning independent testing in virtual and constructive environments. Tomorrow's operational testing requirements must be addressed, now, if the Army is to successfully operate across the simulation continuum in the future.

APPENDIX A

A2 . . . . Anti-Armor
AAE . . . . Army Acquisition Executive
ADATS-A . . . . . Acq and Dev of Threat Simulators Activity
AH . . . . Attack Helicopter
AMC . . . . Army Materiel Command
AMSAA . . . . Army Materiel Systems Analysis Activity
ARL . . . . Army Research Laboratory
ARPA . . . . Advanced Research Projects Agency
ASA . . . . Assistant Secretary of the Army
ASA(RD&A) . . . . ASA (Research, Development & Acquisition)
ASARC . . . . Army Systems Acquisition Review Council
ATCOM . . . . Aviation and Troop Command
ATD . . . . Advanced Technology Demonstration

BDS-D . . Battlefield Distributed Simulation - Developmental
BLG . . . . Battle Labs Guide
CCTT . . . . Close Combat Tactical Trainer
CD . . . . Combat Developments
CEP . . . . Concept Evaluation Program
COEA . . . . . Cost and Operational Effectiveness Analysis

DAB . . . . Defense Acquisition Board
DACM . . . . Director, Acquisition Career Management
DIS . . . . Distributed Interactive Simulation
DMSO . . . . Defense Modeling and Simulation Office
DoD . . . . Department of Defense
DPG . . . . Defense Planning Guide
DSI . . . . Defense Simulation Internet
DUSA . . . . Deputy Under Secretary of the Army
DUSA(OR) . . . . DUSA (Operations Research)

FY . . . . Fiscal Year
FYDP . . . . Future Years Defense Program

GAO . . . . Government Accounting Office
GOCO . . . . Government Owned - Contractor Operated

IEEE . . . Institute of Electrical and Electronic Engineers
IST . . . . Institute for Simulation and Training

JT&E . . . . Joint Test and Evaluation

LAM . . . . Louisiana Maneuvers
LAN . . . . Local Area Network

LTG . . . . Lieutenant General

M&S . . . . Modeling and Simulation
MAA . . . . Mission Area Analysis
MACOM . . . . Major Command
MICOM . . . . Missile Command
MILDEP . . . . Military Deputy
MNS . . . . Mission Need Statement
MS . . . . Milestone

O&M . . . . Operations and Maintenance
OEC . . . . Operational Evaluation Command
OMB . . . . Office of Management and Budget
OPTEC . . . . Operational Test and Evaluation Command
ORD . . . . Operational Requirements Document
OSD . . . . Office of the Secretary of Defense
OT&E . . . . Operational Test and Evaluation
OTEA . . . . Operational Test and Evaluation Agency

PDU . . . . Protocol Data Unit
PEO . . . . Program Executive Officer
P_H . . . . Probability of Hit
P_K . . . . Probability of Kill
PM . . . . Program Manager
POM . . . . Program Objective Memoranda
PPBS . . . . . . Planning, Programming and Budgeting System

R&D . . . . Research and Development
RAH . . . . Reconnaissance and Attack Helicopter
RDEC . . . . . Research, Development and Engineering Center
RDT&E . . . . Research, Development, Test & Evaluation

S&T . . . . Science and Technology
SAFOR . . . . Semi-Automated Forces
SIMNET . . . . Simulation Network
STEP . . . . Software Test & Evaluation Panel
STRICOM . . Simulation, Training and Instrumentation Command

T&E . . . . Test and Evaluation
TACOM . . . . Tank and Automotive Command
TECOM . . . . Test and Evaluation Command
TEMP . . . . Test and Evaluation Master Plan
TEXCOM . . . . Test and Experimentation Command
TRAC . . . . TRADOC Analysis Command
TRADOC . . . . Training and Doctrine Command
TSM . . . . TRADOC System Manager

VV&A . . . . . Verification, Validation, and Accreditation

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